Industrial Psychology

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To my esteemed teachers

LIGHTNER WITMER

and

EDWIN BURKETT TWITMYER

this book

is

gratefully dedicated

PREFACE

Approximately twenty years ago Münsterberg presented the first systematic formulation of the problems and scope of an industrial psychology. At that time he could present little in the way of direct evidence to support the thesis that efficiency and adjustment in industry could be improved through the application of psychological principles and techniques. Today there is available a wealth of experimental data, obtained in industrial investigations, to illustrate the concrete achievements of the science in increasing the effectiveness and happiness of man in industry.

In a sense, industry has been turned into a vast laboratory in which has been investigated every aspect of human behavior involved in adjustment to the industrial situation. The methods and apparatus of traditional laboratory psychology have been employed in these studies. To these have been added new techniques, new equipment, new viewpoints, which have not only enriched our knowledge of human behavior in industry, but have thrown light on general principles of interest to the psychologist regardless of the field of investigation in which he may be engaged. It may truly be said that the scope of industrial psychology is as extensive as that of psychology itself, the chief difference being the specific situation with which the latter is concerned.

By reason of this overlapping, the reader will find discussed in this volume many of the fundamental problems of general and applied psychology. These problems are invariably treated in relation to the industrial situation, and, in general, only such experimental results presented which have a direct bearing on this situation. However, these findings apply and have a tremendous significance in all fields of applied psychology.

The guiding principle in the selection of material for this volume has been the desire to present a comprehensive picture of modern industrial psychology. The objective has been that of showing the genesis, the problems, the settings, the findings, and the accomplishments of this newer application of psychology. European literature has been carefully surveyed for a description of the very important work which is being done in Germany, France, England, Italy, etc., and which has been somewhat neglected in other treatments of this topic. The author has drawn upon his own experience as a consulting psychologist in industry, and upon his personal observations in visiting American and European centers of industrial psychology, as a guide in the interpretation of results and tendencies.

In order that the available space in this volume might be completely devoted to psychological methods, findings, etc., which are of specific

value in the industrial situation, the detailed discussion of statistical techniques, which frequently takes up many pages in volumes on applied psychology, has been carefully avoided. Such techniques have been adequately discussed in standard texts on statistics, to which the interested reader can refer without great difficulty. The orientation with respect to the relation of man to machine, with respect to the consideration of the individual in the conflict between individual welfare and economic efficiency, appears in the Introduction (Chapter I) and throughout the text, and need not be further discussed here.

Inasmuch as a large portion of this text is devoted to reports of studies by other investigators, the author is naturally indebted to many who have indirectly contributed towards its preparation. He is directly indebted to the publishers named on page 629, to the editors of many journals, as well as to individual investigators for permission to republish certain tables, figures, and other data. Acknowledgment must be particularly made to the Controller of H. M. S. Stationery Office for permission to reproduce considerable material from publications by the *Industrial Fatigue (Health) Research Board*, and to the editors of *Psychotechnische Zeitschrift*, *Industrielle Psychotechnik*, and the *Personnel Journal*, from which much material has been drawn.

The author is indebted to Prof. E. S. Robinson, of Yale University, and to Dr. Walter V. Bingham, of the Personnel Research Federation, for reading portions of the manuscript, and to Kinsley R. Smith, of the Department of Psychology, University of Pennsylvania, who has helped in reading proof and in the preparation of the index.

Considerable material for this volume has been drawn from the author's experience as Director of Personnel Research, Philadelphia Electric Company. The author desires to express his acknowledgment to the Management of that organization, and, in particular, to A. M. Boyd, Manager, Personnel, Claims and Safety Department, who has made individual adjustment the dominant objective in the scientific study of personnel problems. The author's associations with E. S. Higgins, Vice President, Parmelee System, Inc., have furnished opportunities for many experimental studies reported in this volume, and have been a constant source of inspiration in this work.

Beyond all, is the stimulating influence of two outstanding teachers at the University of Pennsylvania—Lightner Witmer and Edwin Burkett Twitmyer—to whom this volume is gratefully dedicated.

Morris S. Viteles

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THE FOUNDATIONS OF INDUSTRIAL PSYCHOLOGY

I. INTRODUCTION TO A STUDY OF INDUSTRIAL PSYCHOLOGY

MAN AND MACHINE

The beliefs and concerns of an age are invariably reflected in its paintings. Saints and sinners, heaven and hell, with here and there a pagan god, fill the canvasses of the Renaissance painters. Formal gardens, scenes of courtly grace, the sweeping lines of hooped skirts, the furtive embrace, flow from the brushes of gifted artists in the retinues of the French Louis. Modern paintings, and the black and white of the lithographer and etcher show not only incomprehensible splashes of color and confusions of forms, but the majestic, overwhelming power of the tremendous dynamo, the intricacies of revolving gears, the cathedral halls of steel mills streaked by the play of flames and heated metal.

Not only the industrialist, but the writer, the painter, and the musical composer sing the paeon of the Machine and bow in humility to the omnipotence of the new appliance—the new Machine that easily achieves things impossible to our fathers, that does much of our work and saves us the tedious labors of the past. It is as if the story of Aladdin's lamp had suddenly come true, and the Spirit of the Lamp were at our call, prepared to do our bidding.[1] It has been easy to wax ecstatic about the Machine and its wonderful possibilities; to vie and even outdo the Victorians in vivid and sentimental panegyrics on the progress of mankind upward and onward forever.[2]

So dominant has been the regard for the machine that until very recently the insignificant man placed in an obscure corner of industrial portraits by such etchers as Pennell has been assigned a very minor rôle in the evaluation of factors responsible for the development of modern industry and for the success of our industrial civilization.

Within the past two decades the scientific study of this industrial civilization, and more particularly of the problems of industry, has revealed the true importance of the human factor in industrial organization. Human reactions—of man to man, of man to machine and material—occupy a prominent place in the complex pattern of industrial enterprise. Underlying every industrial process, as mechanized as it may be, and often closely associated with it, are human ingenuity and

control. As marvelously intricate as they may be, machines must be designed, operated, and cared for by men. They must be built with due respect for the physical and mental characteristics of the man who is to operate them. In determining their methods of operation, their speeds, their very construction, the limitations of human rates of speed, of qualities of co-ordination, of human judgment, of the capacity to learn must be taken into consideration. Moreover, the success of our industrial civilization, as well as of individual plants, depends not only upon the worker's skill in the operation of the machine, but also upon such strictly human attributes as his attitude toward them and upon the satisfaction which he obtains in their operation. The accomplishments of the industrial organization are further circumscribed by the human element—by the judgment of the industrial executive, by his ability to understand and direct the human forces in his plant and to integrate the clash of motivation between management and workers.

In its every aspect, the stability of business enterprise depends no less upon the soundness of its psychological foundation than upon the solidity of its economic and technical supports. Without underestimating the rôle of the machine and of other factors, industry must be viewed as an immense arena for the play and interplay of human behavior. The failure to study the character of this phenomenon, to analyze the conditions which influence the effectiveness of human behavior in industry can only result in serious waste in the form of individual maladjustment and of industrial inefficiency.

THE OBJECTIVES OF INDUSTRIAL PSYCHOLOGY

The study of human behavior, with the view of guarding against such waste, is the province of industrial psychology. This volume is devoted to a discussion of the methods employed, the principles evolved, and the results accomplished by industrial psychology in promoting the better adjustment of man in industry and increased industrial efficiency.

In considering the scope of this volume on industrial psychology it is important to note the statement on the objective of industrial psychology included in the preceding sentence. In formulating a program of industrial psychology the maximum *efficiency* of the individual in industry and his optimum *adjustment* are looked upon as complementary facets of a single objective. The industrial psychologist is primarily concerned with the individual at work in the belief that, in the final analysis, the maximum efficiency of that individual in the industrial situation can only be achieved by insuring his most satisfactory adjustment in that situation. Moreover, it is necessary to stress the welfare of the individual not only because of the direct effect of maladjustment upon his industrial efficiency, but also by reason of indirect

adverse effects in the form of maladjustment in other social relationships which may follow from inefficiency or dissatisfaction in work.

SCOPE OF THIS VOLUME

The first section of this volume is devoted to a discussion of the foundations of industrial psychology. The scope and present status of the science, the rapidity of its development, can only be fully understood by considering *economic, social,* and *psychological* factors which have contributed to this development. The discussion of these factors is followed by two chapters on *individual differences*. A brief survey of the nature and origin of such differences is essential to an adequate comprehension of the specialized procedures provided by psychology for promoting individual welfare and efficiency in industry.

The second section of the text is devoted to the study of occupational qualifications and to the development and application of techniques for their measurement as an aid in the *scientific selection and placement* of industrial personnel. This section includes not only a discussion of the procedures which have been employed by the industrial psychologist and an analysis of underlying principles, but also a brief survey of results which have been obtained in industry through their application at various occupational levels.

Chapters on the place of *psychology in promoting the safety* of industrial personnel open Section III, which is devoted to problems arising in maintaining fitness at work. These are followed by a detailed consideration of psychological problems in *training workers*. A competent applicant for employment may become a very unsatisfactory and dissatisfied worker because he has not been properly trained. The recognition of this is leading industry to substitute for the older method of training, in which the instruction of the worker was left largely to the caprice of the foreman or to some other minor supervisory official, a more scientific procedure in which instruction is centralized in the hands of a corps especially fitted for this task. The general phases of this movement are not treated in detail in this volume. However, it does include a comprehensive survey of the contributions which psychology has made to the solution of the practical problem of properly training workers in industry. In this connection both laboratory and industrial investigations on habit formation, on the influence of the whole and part methods of work, on the influence of incentives, etc., are discussed in considerable detail.

Other chapters are devoted to a consideration of such important factors in human adjustment in industry as *monotony, fatigue, the feelings and motivation of workers*. These chapters are concerned with investigations of the best methods of applying human energy and ability to reduce monotony and fatigue, to increase interest, etc. *Maladjustment* as a general problem and the comparative merits of the

psychological and psychiatric approach in its prevention and elimination are treated in one chapter of Section III. Findings on the *psychology of management* are included in a chapter which brings the volume to a close.

A text on psychology in industry may be expected to include a discussion of the application of psychology in selling and advertising. In this respect this volume on industrial psychology is incomplete. The problems in selling and advertising are so distinctive, the psychological techniques so specialized and so largely concerned with group reactions, that it has seemed well to omit them from this book, which will concern itself only with the application of psychology in promoting industrial efficiency through improved individual adjustment.

POINTS OF VIEW

A resumé of the objectives and content of this text in industrial psychology would not be complete without a brief reference to one or two of the points of view by which the author has been guided in writing it. In the first place, the reader of this introductory chapter will readily recognize that the orientation of this volume will not be merely *statistical,* in the interpretation of mass data, but *clinical,* in its emphasis on the individual with whom the psychologist must be primarily and ultimately concerned.

The bias of this text is distinctly *experimental.* The growth of interest in psychology, particularly as applied in industry, has been accompanied by the formulation of broad generalizations, phrased in psychological jargon, which have, in fact, little validity in the explanation of human behavior in industry. In the treatment of data in this volume, generalizations will be limited to only those which can legitimately be drawn on the basis of observed facts. On the other hand, findings will not be presented as isolated facts, but in relation to their wider industrial, social, and philosophical implications.

In the preparation of this volume a very careful survey has been made of investigations in the field of industrial psychology in both the United States and Europe. Those selected for detailed discussion in this book are not necessarily the only investigations of their kind. They have been selected not only on the basis of merit, but by reason of representativeness, or priority, etc., and because of other factors which do not reflect adversely upon those omitted or receiving only brief mention. Many of the latter are well worth careful study not only by the professional student of applied psychology, but by the casual reader.

In the preparation of this volume material has also been selected and presented with a view of its usefulness:

(a) To advanced undergraduate and graduate students of applied psychology, to whom it will have a special appeal by reason of the

multiplicity of facts made available in it and of the many illustrations of the every day application of psychological principles formulated in the laboratory.

(b) To teachers, not only of psychology, but of sociology, economics, industrial management, and of allied subjects involving a consideration of the individual at work.

(c) To executives in industry who are interested in a clear but not superficial, a comprehensive but not complex, and an analytical but not abstruse survey of the psychological basis of human behavior in industry.

II. THE ECONOMIC FOUNDATIONS OF INDUSTRIAL PSYCHOLOGY

In the development of industrial psychology three distinct forces have played a part, *economic, social,* and *psychological.* The interplay of these forces has not only accounted for the growth of the science in the last twenty years, but differences in their balance have produced a variety of viewpoints with respect to the functions and responsibilities of industrial psychology. So, for example, in Germany, left in a state of severe privation by the war, economic objectives have been most powerful in determining the procedures and viewpoints of industrial psychology. In England, the active interest of a socially awakened laboring class has undoubtedly influenced the character and aims of investigations in this field. Similarly, in the United States, the development of the science has been tremendously colored by the long strides taken in the formulation of a psychology of the individual—in itself, perhaps, a reflection of the individualistic bias of the economic, and to a lesser extent of the social structure of the nation. The purpose of this and the two succeeding chapters is to sketch in broad lines the play of each of these forces in the development of psychology in industry.

ECONOMIC BASIS OF INDUSTRIAL PSYCHOLOGY

The advancement of efficiency in industry is one of the chief objectives of industrial psychology. In every enterprise where goods are produced, increased production at lower cost has been the chief consideration in guiding the destinies of the enterprise. The rapid growth of merchandizing units in recent years is an outgrowth of the almost universal adoption of this guiding principle by industry, and the very existence of highly developed and highly complicated merchandizing organizations has further stimulated the urge toward increased production at lower costs. As a matter of fact, industry has largely accepted psychology as an aid because of what it can contribute toward the cheaper production and merchandizing of goods. Too often its accomplishments in the direction of improved individual adjustment have been regarded as very desirable and valuable, but, on the whole, not altogether necessary by-products in the attainment of the chief objective of increasing efficiency. In this viewpoint the industrial ex-

ecutive has been supported by a group of psychologists to whom an increase of efficiency and a decrease of production and distribution costs represent the sole motives for the study of human behavior in industry.

In later chapters will be cited specific instances of investigations in which the economic motive has been most in evidence in the promotion of industrial psychology. The present chapter will be limited to a general analysis of the economic influence in its development. This influence has its origin in the changing viewpoint with respect to the relative importance of *Man* and *Machine* in the industrial situation.

The acceptance of psychology by industry represents a tacit admission that the machine, heralded as the sole need of an industrial era, is insufficient in itself to meet the demands of an industrial civilization. It is a recognition that, perfect as they may be, machines can only be used to advantage by properly selected, adequately trained men, conversant with methods for most effectively employing the energy at their disposal and willing to do so.

In order to promote greater and cheaper production, to cater to our increasing wants, ingenuity and inventiveness in perfecting machines must be supplemented by a more complete utilization of human energy, human ability, and human motives. "We have been very much occupied," wrote Dupin, as early as 1829, "in perfecting the machines and the tools which the worker uses in the economic arts. We have hardly attempted to improve the worker himself. However, if he were only considered as an instrument, a tool, a motor, he would necessarily be placed in the first rank of all instruments, all mechanical agents, since he has the immeasurable advantage of being an instrument who observes and corrects himself, a self-stopping motor which functions with the motivation of its own intelligence and which perfects itself by thinking not less than by work itself." [1]

THE INFLUENCE OF TAYLOR UPON THE DEVELOPMENT OF INDUSTRIAL PSYCHOLOGY

The Principles of Scientific Management

In spite of the early recognition of this problem by Dupin and others, it remained for an American engineer, Frederick W. Taylor, to take the first definite step in the rationalization of human methods of work. Taylor, starting toward the end of the 19th century, first gave to this factor in production the same careful attention which, from the beginning of the Industrial Revolution, had been devoted to the perfection of the machine.[2] He became the pioneer of the movement which

has spread throughout the entire world under the names of *Taylorism* and of *Scientific Management*.[3]

In the development of his system Taylor starts with two assumptions. The first is that "what the workmen want from their employers beyond anything else is high wages, and what employers want from their workmen is a low labor cost of manufacture." [4]

The second is that "no system or scheme of management should be considered which does not in the long run give satisfaction to both employer and employee; which does not make it apparent that their best interests are mutual and which does not bring about such thorough and hearty co-operation that they can pull together instead of apart."

His major contribution to industrial efficiency grows out of the application in industry of four fundamental practices:

1. *The development of a science for each element of a man's work to replace the old rule of thumb methods.*

2. *The selection of the best worker for each particular task followed by a program for training the workman to replace the practice of allowing the worker to select his own task and train himself as best he can.*

3. *The development of a spirit of hearty co-operation between the management and the men in carrying on their activities in accordance with the principles of the developed science.*

4. *The division of the work in almost equal shares between the management and the workers, each department taking over the work for which it is better fitted as a substitute for the condition in which almost all the work and the greater part of the responsibility were thrown on the men.*[5]

To these principles must be added the provision, implied in all of Taylor's work, that their application must result in higher wages for the worker, as an incentive to his co-operation in the plan, as well as in increased production at lower costs.

APPLICATION TO HANDLING PIG-IRON

The first practical application of Taylor's principles was made in his classic experiment in selecting and training men to handle pig-iron. The work was carried on in the plant of the Bethlehem Steel Company. At the time of the experiment there were in operation five blast furnaces, the product of which had been handled by a pig-iron gang for many years. This gang, at the time Taylor started his work, consisted of about 75 men. "They were good, average pig-iron handlers,

[3] For a survey of viewpoints, scope, and accomplishments of scientific management see *Scientific Management in American Industry*, New York, 1929, pp. 479 (issued by the Taylor Society).

[4] F. W. Taylor, *Shop Management*, New York, 1911, p. 21.

[5] G. D. Babcock, *The Taylor System in Franklin Management. Application and Results*, New York, 1917. p. 17.

were under an excellent foreman who himself had been a pig-iron handler, and the work was done, on the whole, about as fast and as cheaply as it was anywhere else at that time." [6] The work of handling pig-iron was done by men with no other implements than their hands. The pig-iron handler stooped down, picked up a pig weighing about 92 pounds, walked for a few feet or yards, and then dropped it on to the ground, or upon a pile. Taylor believed this work to be so crude and elementary in its nature that it would be possible to train an intelligent gorilla to become a more efficient pig-iron handler than any man can be. And yet he felt that the science of handling pig-iron, in spite of the crude character of the work, is so great, that this type of work could be used to illustrate the accomplishment to be derived from properly training competent workers in the best methods of work.

When Taylor started to apply his principles he found that the gang of laborers employed in loading pig-iron onto a railroad car were averaging approximately 12½ long tons per man per day. After carefully observing the methods of work and studying the number of voluntary pauses, etc., he reached the conclusion that a first class pig-iron handler ought to handle between 47 and 48 tons per day instead of 12½ tons. Taylor questioned many good managers and asked them whether, under premium work, piece work, or any of the ordinary plans of management, they would be likely ever to approximate 47 tons per day. Not a man suggested that an output of over 18 to 25 tons could be obtained by any of the ordinary expedients.

Taylor then set about to choose a worker on whom he could first try out his new methods. He finally selected a Pennsylvania Dutchman whose reputation, habits, and ambition made him seem a likely subject. This man was asked whether he would prefer earning $1.85 per day to the $1.15 which constituted his pay check at the time. He was told he could do so by loading in one day a pile of pig-iron (consisting of 47½ tons) which was pointed out to him. He was further cautioned that in order to load this pile of pig-iron and to earn his increased pay, he must carefully follow the instructions of the man assigned to train him in the proper method of doing this work. He started to work, and all day long, and at regular intervals, was told by the man who stood over him with a watch; "Now pick up a pig and walk. Now sit down and rest. Now walk—now rest," etc. He worked when he was told to work, and rested when he was told to rest, and at half past five in the afternoon had his 47½ tons loaded on the car. He practically never failed to work at this pace and to do the task that was set him during the three years of observation by Taylor. And throughout this time he averaged a little more than $1.85 per day, whereas before he had never received over $1.15 per day, which was the ruling rate of wages at that time in Bethlehem.

One man after another was picked out and trained to handle pig-

[6] F. W. Taylor, *The Principles of Scientific Management*, New York, 1911, p. 42.

iron at the rate of 47½ tons per day until all of the pig-iron was handled at this rate, and all of the men still working in the gang received 60% more wages than that paid to other men around them who were not employed on task work. However, of the gang of "seventy-five pig-iron handlers, only about one man in eight was found physically capable of handling 47½ tons per day. With the very best of intentions the other seven out of eight men were physically unable to work at this pace." [7]

The selection of the specially competent represents, according to Taylor, one of the fundamental responsibilities of scientific management. Incidentally, it is pointed out by Taylor that the removal of men from jobs for which they are unfit is a kindness to such men, representing a first step toward finding them work for which they are better fitted and at which, after training, they can permanently and legitimately earn higher wages. The selection of competent men must be followed by training each man, under a proficient teacher, into new working habits until he continually and habitually works in accordance with scientific laws developed from a careful survey of the job by a trained observer. Superimposed upon such selection and training is a system of financial incentives and of superior plant organization and control designed to make permanent and constant the ecomomic advantages gained from the application of these two fundamentals of scientific management.

In another experiment at the Bethlehem Steel Company, Taylor was able, by a proper selection of shovelers, by carefully instructing each worker in the proper method of handling the tool, by providing shovels suitable for the different kinds of material which the worker was called upon to handle, and by providing higher wages for increased production, to effect a marked improvement in efficiency on the part of such workers. The results obtained in the third year of work under the new plan of task work devised by Taylor, in contrast to those obtained under the old plan, are shown in Table 1.

TABLE 1

Improvements in Efficiency under Scientific Management

(Bethlehem Steel Company)

The number of yard laborers was reduced from between	400 & 600	to	about 140
Average number of tons per man per day increased from	16	to	59
Average earnings per man per day increased from	$1.15	to	$1.88
Average cost of handling a ton of 2240 lbs. decreased from	$0.072	to	$0.033

(From F. W. Taylor)

[7] *Ibid.*, p. 47.

"During this year the total saving of the new plan over the old amounted to $36,417.69, and during the six months following, when all of the work of the yard was on task work, the saving was at the rate of between $75,000 and $80,000 per year." [8]

IMPROVING THE OUTPUT OF BALL BEARING INSPECTORS

The work of Thompson in improving the quantity and quality of the output of ball bearing inspectors is cited by Taylor as another example of the possibilities of scientific management in making more effective use of the energy employed by the worker in his daily tasks. In this instance, after the introduction of changes in the form of standard working conditions, of rest pauses, of improvements in methods of work (determined in part through the use of the stop watch in time studies), and through proper selection, it was found that 35 girls were able to do the work formerly done by 120 and that the accuracy of the work at the higher speed was greater than at the former slow speed. It is interesting to note the advantages which accrued to the workers from the introduction of these changed methods.

"1. They averaged from 80 to 100 per cent higher wages than they formerly received.

2. Their hours of labor were shortened from 10½ to 8½ per day, with a Saturday half holiday. And they were given four recreation periods properly distributed through the day, which made overworking impossible for a healthy girl.

3. Each girl was made to feel that she was the object of special care and interest on the part of the management, and that if anything went wrong with her she could always have a helper and teacher in the management to lean upon." [9]

IMPROVING BRICKLAYING METHODS

In bricklaying is found another classic example of the application of principles first formulated by Taylor. Bricklaying is one of the oldest of our trades. For hundreds of years there had been little or no improvement in the implements and materials used in this trade or in the method of laying bricks [10] until Frank B. Gilbreth (a disciple of Taylor), who had himself studied bricklaying in his youth, became interested in the principles of scientific management and decided to apply them to the art of bricklaying.[11] He made a detailed analysis of each movement of the bricklayer, and one after another eliminated all unnecessary movements and substituted fast for slow motions. He ex-

[8] *Ibid.*, p. 71.
[9] *Ibid.*, pp. 95–96.
[10] *Ibid.*, pp. 77–79–81.
[11] F. B. Gilbreth, *Bricklaying System*, New York, 1909.

perimented with every minute element which in any way affects the speed and the tiring of the bricklayer.

He developed the exact position which each foot of the bricklayer should occupy with relation to the wall, the mortar box, and the pile of bricks, and so made it unnecessary for him to take a step or two toward the pile of bricks and back again each time a brick is laid. He studied the best height for the mortar box and brick pile, and then designed a scaffold, with a table on it, upon which all of the materials are placed, so as to keep the bricks, the mortar, the man, and the wall in their proper positions. These scaffolds are adjusted for all of the bricklayers, as the wall grows in height, by a laborer especially detailed for this purpose. By this means the bricklayer is saved the exertion of stooping down to the level of his feet for each brick and each trowelful of the mortar and then straightening up again. This simple device has eliminated an immense waste of effort that has gone on through all these years, with each bricklayer lowering his body, weighing, say, 150 pounds, down to 2 feet and raising it up again every time a brick (weighing about 5 pounds) is laid in the wall! And this each bricklayer did about one thousand times a day.

As a result of further study, after the bricks are unloaded from the cars they are carefully sorted by a laborer and placed with their best edge up on a simple wooden frame, constructed so as to enable the bricklayer to take hold of each brick in the quickest time and in the most advantageous position. In this way he avoids either having to turn the brick over, or end for end to examine it before laying it, and he saves, also, the time taken in deciding which is the best edge and end to place on the outside of the wall. In most cases, moreover, he saves the time taken in disentangling the brick from a disorderly pile on the scaffold. This "pack" of bricks (as Gilbreth calls his loaded wooden frames) is placed by the helper in its proper position on the adjustable scaffold close to the mortar box. Furthermore Gilbreth found that by tempering the mortar just right the bricks could be readily bedded to the proper depth by a downward pressure of the hand with which they are laid. He insisted that mortar mixers should give special attention to tempering the mortar and so save time consumed in tapping the brick.

Through this minute study of the motions to be made by the bricklayer in laying bricks under standard conditions, Gilbreth reduced the movements from 18 per brick to 5, and even in one case to as low as 2 motions per brick. In an early demonstration on a commercial scale of the great gain which is possible from practically applying his scientific study Gilbreth, with union bricklayers, showed that in laying a factory wall, 12 inches thick, with 2 kinds of brick, faced and ruled joints on both sides of the wall, he averaged, after his selected workmen had become skillful in his new methods, 350 bricks per man per hour; whereas the average speed of doing this work with the old methods was, in that

section of the country, 120 bricks per man per hour. His bricklayers were taught the new methods of bricklaying by their foremen. Those who failed to profit by their teaching were dropped, and each man, as he became proficient under the new method, received a substantial (not a small) increase in his wages. With a view to individualizing his workmen and stimulating each man to do his best, Gilbreth also developed an ingenious method for measuring and recording the number of bricks laid by each man, and for telling each workman at frequent intervals how many bricks he had succeeded in laying.

OTHER ASPECTS OF SCIENTIFIC MANAGEMENT

Although Taylor's first and chief interest was the improvement of methods of work, he recognized that in addition to this it was extremely important to provide the worker with the most satisfactory tools and conditions of work. This he felt was necessary not only to insure an increased return to the worker from the use of improved methods, but also to increase further the operating efficiency of the plant. His renowned experiment on determining the best kind of cutting tool for each of the many different conditions encountered in working on metals is an outstanding example of his concern with the adequacy of the tools furnished to the worker. To insure the most satisfactory conditions for increased production Taylor recommended a number of procedures which have become an established part of the scientific management program. Among these may be cited:

1. Time study, with the implements and methods for properly making it.
2. Functional or divided foremanship.
3. The standardization of all tools and implements used in the trades (as well as the acts or movements of workmen for each class of work.)
4. The establishment of a planning room or department.
5. The "exception principle" in management.
6. The use of slide-rules and similar time-saving implements.
7. Instruction cards for the workman.
8. The task idea in management, accompanied by a large bonus for the successful performance of the task.
9. The "differential rate."
10. Mnemonic systems for classifying manufactured products as well as implements used in manufacturing.
11. A routing system.
12. Modern cost system, etc., etc.

In his development of these principles of scientific management and in their application the founder of scientific management pointed to the need of "another type of scientific investigation—which should re-

ceive special attention, namely, the accurate study of the motives which influence man—Laws which apply to a large majority of men," Taylor points out, "unquestionably exist, and when clearly defined are of great value as a guide in dealing with men." [12] At the same time, in the practical application of his system, increased pay for a higher rate of speed constituted the only incentive employed in elevating the worker to the high standards of efficiency demanded by the system.

Taylor failed to submit to experimental analysis the motivating factors which are present in man and influence his effectiveness in work. He also gave no consideration to an experimental study of the nature of the skill with which he primarily concerned himself. For these reasons Taylor contributed little to the theory and procedures of psychology as applied in industry. However, his emphasis on the human factor was extremely influential in preparing the ground for industrial psychology. Moreover, his point of view and methods have both directly and indirectly affected its scope, objectives, and the direction of its growth.

THE SOCIAL IMPLICATIONS OF THE TAYLOR SYSTEM

A summary of the contributions of Taylor would be incomplete—and is perhaps only too often left incomplete—without a reference tc the social philosophy which guided him in the development of his principles. "The greatest material gain which those of the present generation have over the past generations has come from the fact that the average man in this generation, with a given expenditure of effort, is producing two times, three times, even four times as much of these things that are of use to man as it was possible for the average man in the past to produce. This increase in the productivity of human effort is, of course, due to many causes, besides the increase in the personal dexterity of the man. It is due to the discovery of steam and electricity, to the introduction of machinery, to inventions, great and small, and to the progress in science and education. But from whatever cause this increase in productivity has come, it is to the greater productivity of each individual that the whole country owes its greater prosperity." [13]

"The general adoption of scientific management would readily in the future double the productivity of the average man engaged in industrial work. Think of what this means to the whole country. Think of the increase," he writes, "both in the necessities and luxuries of life, which becomes available for the whole country, of the possibility of shortening the hours of labor when this is desirable, and of the increased opportunities for education, culture, and recreation which this implies. But while the whole world would profit by this increase in production, the manufacturer and the workman will be far more interested in the especial local gain that comes to them and to the people imme-

[12] F. W. Taylor, *op. cit.*, pp. 129–30.
[13] *Ibid.*, p. 141.

diately around them. Scientific management will mean, for the employers and the workmen who adopt it—and particularly for those who adopt it first—the elimination of almost all causes for dispute and disagreement between them. What constitutes a fair day's work will be a question for scientific investigation, instead of a subject to be bargained and haggled over. Soldiering will cease because the object for soldiering will no longer exist. The great increase in wages which accompanies this type of management will largely eliminate the wage question as a source of dispute. But more than all other causes, the close, intimate co-operation, the constant personal contact between the two sides, will tend to diminish friction and discontent." [14]

THE INFLUENCE OF SCIENTIFIC MANAGEMENT UPON THE SCOPE, METHODS, AND AIMS OF INDUSTRIAL PSYCHOLOGY

The work of Taylor and his disciples has tremendously influenced the development of industrial psychology in two directions:—

First, *in guiding somewhat the type of investigations conducted by the industrial psychologist,* that is, *in determining the scope of industrial psychology,* and

Secondly, *in establishing firmly the economic objective of industrial psychology.*

A bulletin issued by the *National Institute of Industrial Psychology of Great Britain* gives the following as the scope of functions of industrial psychology:

1. Study of the requirements of occupations and the elaboration and application of suitable tests so as to secure (a) the scientific selection of workers, and (b) more reliable guidance for children when choosing their life's work.

2. Investigation of the best methods of applying human energy with regard to (a) the elimination of unnecessary movements, (b) advantageous distribution of rest periods, and (c) the reduction of monotony and increase of interest, etc.

3. Realization of conditions (a) in regard to lighting, ventilation, etc., which tend to the maximal health, comfort, and well-being of the worker, and (b) in regard to methods of payment, labor representation, etc., which tend to the best relations between management and labor.

4. Training of workers with reference to the psychological principles involved in learning and habit formation among beginners, the training of foremen, etc.

5. Study of the factors influencing the sale of products, e. g., advertising, designing, etc.

A comparison of this statement with the discussion of the work of Taylor and his disciples included in this chapter shows the extent to which psychologists have absorbed the functions assigned by Taylor to

[14] *Ibid.*, pp. 142–143.

the exponents of scientific management. The industrial psychologists are building upon the foundations laid by Taylor and concerning themselves with the types of problems in which he was interested. However, it is important to point out that although the psychologists are building upon the foundations laid by Taylor, the structure which they are setting up differs very much from the rough plans sketched by Taylor and by other early workers in the field of scientific management. Although recognizing the fundamental soundness of the plan designed to increase human efficiency, psychologists have, at all times, been very critical of the emphasis on efficiency and the relative disregard of human welfare in the proposals and practices for putting the plan into operation adopted by industrial engineers who have taken up the development of scientific management since the retirement of Taylor from active work in approximately 1910. This critical attitude has been responsible for the revision by the industrial psychologist of Taylor's plans in such a way that industrial efficiency may be achieved without the sacrifice of individual welfare. It is as students of human behavior that the psychologists have taken over the work to increase human efficiency in industry through fatigue study, time and motion study, etc. Although, to some extent, they have become advocates of the Taylor system, the psychologists are also the most enlightened and the most severe critics of the Taylor and similar systems for increasing industrial efficiency, in so far as in the application of these systems there may be a tendency to neglect the worker's well-being—to sacrifice his "maximal health" and comfort. This problem will be discussed in greater detail in a later section of this volume.

THE ECONOMIC ASPECTS OF INDUSTRIAL PSYCHOLOGY

Industrial psychology has profited not only from the adoption of the techniques of scientific management but from the demonstration by Taylor that industry can expect a definite return from an investigation and analysis of human behavior. It is partly because Taylor showed that returns to both the management and the worker could be increased through the study of the human element that early psychologists were granted by industry an opportunity to conduct investigations designed to increase human effectiveness in industry. In return industrial psychology has taken on the obligation of scientific management for promoting the efficiency of the individual worker, and in this way contributes to the further development of industrial civilization. The importance of the economic objective is well illustrated in the rapid rise of industrial psychology in Germany at the end of the war. At this time there appeared a pronounced interest in the application of psychology in business which resulted in the establishment of numerous psychological institutes and in the organization of psychological laboratories by private firms. The intensified interest had its root, to some

extent, in the general desire to achieve, as quickly as possible, the economic reconstruction of German industry and of the state itself. Applied psychology found ready acceptance by industrialists and workers alike as a measure which would help in the best utilization of the dwindled man power of Germany. It was recognized that unit cost of production could be decreased only by substituting the most efficient use of human effort for the advantages in low cost of raw material and and large working population possessed by Germany before the war, and that only by thus decreasing cost of production could Germany hope to compete with other manufacturing countries and regain her place in the economic world. Other factors favorable to the development of industrial psychology were also present, but this, more than any other single force, contributed to the growth of the German agencies for the application of psychology in business.

In the United States and elsewhere further illustrations could be furnished to indicate the strength of this economic support to industrial psychology. To one group of psychologists the increased economic return to society, to the industrial plant, and to the worker from the application of psychology in industry constitutes the sole justification for this work. To these psychologists increased efficiency and decreased cost of production represent the only motives for the investigation of human behavior in industry and for the application in this situation of the principles evolved in the psychological laboratory. In contrast is the insistence by other psychologists upon the broader social aims of industrial psychology. "Recognizing that an increasingly greater output of the necessaries of life must ultimately be for the advantage of all, and that secondly, the scientific mechanization and speed-up of industry are fundamentally necessary and natural tendencies of our time which it is futile to oppose, but realizing too, that after all, production is as much for the sake of life as life for the sake of production," [15] this other group of psychologists has stressed elements of individual and social welfare, the significance of which can only be completely understood from a consideration of the *social* and *psychological* foundations of industrial psychology.[16]

III. SOCIAL FOUNDATIONS OF INDUSTRIAL PSYCHOLOGY

The urge for increased production and distribution of goods may be described as the dominant force of the industrial age. As the taste of blood stirs the appetite of a wild beast, the demonstration, in the early days of the Industrial Revolution, of what could be done by machines has stirred us toward greater and greater accomplishment in the mass production of increasingly diversified goods. This has been accomplished, in large part, through the development and use of bigger and better machines. The growing dependence upon the machine, the faith in its powers, combined with the play of such forces as increased labor supply, the individualism of a pioneering era, etc., led, particularly in the early phases of industrialization, to the development of a *mechanistic* orientation with respect to the worker himself. Labor came to be looked upon as a *commodity value* to be gauged by the same standards of maximum use, periodic replacement, and scrapping when damaged or worn out, as was the machine.

This attitude was favored by the social philosophy of the era—the insistence that if each force, most particularly capital and labor, were allowed free play each would automatically find its level and receive its just return in this well ordered world. Such a policy, it was believed, establishes a natural balance between capital and labor, between supply and demand and similar highly complicated and ill-defined supplemental or antagonistic forces, and gives each individual an opportunity to profit most freely from the display of his talents.

Such a policy implies non-interference on the part of social agencies with individual enterprises. In the light of this attitude, the displacement of men by machines could not be viewed as a social problem, but merely as a misfortune to the individual caught and unseated by the free and tempestuous play of uncontrollable forces. There was, of course, the hopeful belief that the cycle would correct itself, that new machines would create new demands, new forms of work, and new jobs in which the displaced workers could find new opportunities. That the temporary poverty and suffering of the individual constituted a social concern was vehemently denied by the exponents of this doctrine of laissez-faire.

The policy of non-interference is well illustrated in the public attitude toward the health and welfare of the worker injured in the industrial plant. Not only was there an absence of provision for medical treatment or for caring for the wants of the worker and his family during the period of illness, but the burden of proving the management's responsibility for an accident was placed directly upon the shoulders of the worker. The acceptance by the court of the plea of contributory negligence on the part of the injured man or of his fellow-workers was fully in accord with the individualistic and mechanistic orientation of the age. The worker paid for this "neglect" not only by loss of work and by suffering, but also too often by pauperization—ultimately paid for by the community—in spite of social smugness in disclaiming interest in what occurred in the industrial plant. Industrial accidents are used in illustration, but the viewpoint with respect to physical and mental health, superannuation, and so on, was similar and could likewise be used in exemplifying the social philosophy of an era which is not yet altogether in the past. "During the nineteenth century industrial development proceeded so rapidly in Europe and America, that the necessity of protecting and conserving the human element in production was scarcely recognized. . . . Economy in the application of capital, replacing of worn out machinery and conservation of natural resources received careful consideration. Waste of human life, accumulation of fatigue and destruction of health in industry received no such attention." [1]

Recent years have witnessed a complete revolution in this viewpoint, an acknowledgment that individual welfare in industry is very much the concern of society. "The economic and social problems created by the appearance of the isolated individual under the conditions of modern industry appeared so insistent and alarming that modifications of the policy of public non-interference were deemed necessary, until, in the last quarter of the century, our comprehensive programs of social betterment, involving a new concept of society's duty to the individual, began to appear." [2] These programs have taken first of all the form of social welfare measures (in some instances administered directly by the State, in others, jointly by State, industry, and workers), such as compulsory compensation in case of accidents, old age pensions, health insurance, and similar devices. The organization of public employment agencies represents another measure taken by society in recognition of its responsibilities for aiding in the adjustment of the individual worker. Such measures express "the assumption that the individual's life is so interknit with conditions quite beyond his control that he can no longer be fully responsible for his individual good or ill. Hence the new assumption—utterly scoffed at in the buoyant individualistic days of discovery and preëmption—that the individual, the business enterprise,

and society should be joint partners in the upkeep of effective and resourceful life." [3]

In addition to measures taken by society, individual employers, especially the managements of the larger industrial organizations, have started to take an interest in husbanding the human resources in industry. This interest undoubtedly grows out of the selfish concern for increased productivity to which attention has been drawn in the preceding chapter. The substitution of improved methods of work for the inadequate procedures adopted by the worker when left to his own devices, the assignment of a definite task, the assurance of a high return for increased production, have not been sufficient to insure the continued efficiency of the worker. It has been found that these essential but limited procedures of the Taylor system must be supplemented by a more careful study of other sources of human proficiency, and by a more extended consideration of other roots of human satisfaction—of the causes of human adjustment and maladjustment in industry, if extended productivity is to be obtained.

The historical development of this viewpoint has been succinctly summarized by Person.[4] "We find little evidence," he writes, "that there was a consciousness of a problem of industrial relations half a century ago. Then in the eighties came big-scale enterprise and the realization of the difficulty of supervising workers, and industry began to seek for incentives to replace supervision in differential wage systems. The practical problems of co-ordination, of good will, and incentive increased as industry became more complex, theories began to be formulated, a circular reaction between these set up. By 1900, a few executives with vision had begun to make noteworthy experiments in industrial government, and a decade later a Robert Valentine or a Robert Wolf was making the problem of relations with workers the essential element of his industrial philosophy. Then came the war with the problem of hiring, the propaganda which made labor more conscious of its function and power, the restriction of immigration and the diminution of the margin of free labor, new theories and new problems with their circular reactions, and now many executives are convinced that the problem of management is the problem of men."

It is true that selfish interests first led management to focus attention on the human element. It is also probably true "that employers who start to care for the health or well being of their employees, because it pays to do so become so much interested in this new enterprise that they eventually do it because they like to do it." [5] However, this solicitude for the individual worker has unquestionably been further

fostered by the changing social philosophy—by the growing insistence that individual welfare be made the central objective of social activities—whether they be industrial, political, or educational in character.

THE ORGANIZATION OF PERSONNEL DEPARTMENTS

The employer's selfish interest, supplemented by the impact of this changing social philosophy, has led to the development in industry of specialized agencies and procedures designed to safeguard and to make most effective use of its man power. Responsibility for these functions has been generally assigned to a relatively new department of the industrial organization—a *Personnel Department,* established "to direct and co-ordinate human relations with a view of getting the maximum production with the minimum of effort and friction and with *proper regard for the genuine well being of the worker*" [6] (italics by the author). It is not within the scope of this volume to sketch the history of personnel management or describe fully the organization and administrative procedures of the personnel department. The beginning of the personnel department is to be found in centralized employment offices, established when the size of the plant, the specialization of labor and of supervision made it necessary to transfer the hiring function from the plant owner, manager, or foreman to some individual especially designated to perform this task. Such centralization created a need for a study of the job, or job analysis, by means of which the duties and qualifications of the many jobs in the plant could become known to the individuals responsible for selecting workers. To these were gradually added the duties of providing suitable medical examination and care, certain welfare activities, etc. Finally "War conditions called attention more or less dramatically to the need of *scientific* personnel administration and . . . lately, the field has come to be recognized as a definite phase of management's administrative function, and like other functions, has become specialized. The same reasons that demand the centralization of responsibilities under a production manager, a sales manager, a research manager, and similar staff heads, also demand that responsibility for the direction of human effort should be centralized under a personnel director." [7] The wide range of responsibilities of the personnel director, of the activities conducted by a personnel department in promoting the welfare and efficiency of workers is shown in Figure 1, representing the functions and administrative divisions of a completely equipped personnel department.

Industrial psychology represents, in part, a response to the same social forces which have contributed to the development of personnel administration. It represents perhaps a refinement of the ordinary processes of personnel administration—the application, in industry, of ex-

IV. THE PSYCHOLOGICAL FOUNDATIONS OF INDUSTRIAL PSYCHOLOGY

The application of psychology in industry grows out of the impact of economic and social forces discussed in earlier chapters. It has been made possible also by changes in orientation and in methods of the science itself.

The theoretical supports of a science and its technical development are in large part influenced by its philosophical foundations. By this is meant the orientation of the science toward its own content and methods and toward other sciences, technologies, and doctrines with which it makes contact. The importance of philosophical foundations is well illustrated in the general history of science. So long as astronomy was limited by a belief in a universe created for men, with earth, inhabited by men, as its center, this science could not achieve the heights of discovery that have characterized it since this point of view has been abandoned and imagination projected into the space beyond the earth. Chemistry enchained to a philosopher's stone remained alchemy. Anatomy and physiology in the hands of a church antagonistic to human dissection, on religious and philosophical grounds, could not uncover the essential facts upon which the important technical contributions of these sciences are based.

THE EXPERIMENTAL BASIS OF PSYCHOLOGY

Of primary importance in the development of industrial psychology is the shift in orientation of psychology from a logical to an experimental basis. Psychology started as a "rational" system. Its problem was to apply reasoning in arriving at a knowledge of psychic life. "Rational psychology took the form of philosophical speculation with respect to the value of consciousness and the origin of the soul. . . . As interesting and as worthwhile as this speculation may have been, it contributed little to the development of a science of human behavior." [1] Psychology conceived as a logical, instead of as an experimental system, could make but meagre contributions toward a valid analysis of human conduct. It could, in addition, find little favor in industrial circles—among engineers trained in the physical sciences, priding themselves upon their dependence on the realistic facts of production records, of

[1] W. Weber, *Die Praktische Psychologie im Wirtschaftsleben,* Leipzig, 1927, p. 1.

accounting sheets and of the testing laboratory—and little concerned with the ratiocinations of arm-chair philosophers.

The change in orientation of psychology from a rational to an experimental basis is a phenomenon of the last half century. The history of the transformation cannot be told here, although its character can perhaps be illustrated by a brief reference to the activities of Wilhelm Wundt, whose most important service to psychology was to give it an experimental turn. The forces which grasped the study of human conduct from the hands of the philosophers and of the mystic, and moulded it into the form of an experimental science devoted to the stuay of observable and measurable phenomena, were active for a century before Wundt became interested in psychology as science. They had expressed themselves in the fields of biology, physiology, and physics and in the gradual delimitation, within each of these fields, of a series of investigations with a definitely "psychological cast of thought." Other German investigators, notably Gustav Theodor Fechner, had already stressed the experimental foundations of psychology and had sketched the concept of psychology as a distinct science with a definite field of research and with its own specialized experimental methods. However, "Wundt was probably the most complete expression in his time of the scientific forces that were remaking psychology. He was one of those men who are great because they recognize the complicated intellectual forces that are developing about them, realize where they are tending, and undertake a synthesis of them. Wundt was the fulfilment, not the origin, of the movement with which his name is associated. But to bring such a movement to its fulfilment, and outline with vigor and earnestness the conception of an experimental psychology which should take its place among the natural sciences, was an achievement of such magnitude as to give him a unique position among the psychologists of the modern period." [2]

Wundt's interest in an experimental psychology, employing scientific methods in collecting and correlating facts, found objective expression in the establishment, in Leipzig, in 1879, of the first laboratory specifically devoted to psychology,[3] and in the foundation, in 1881, of the first periodical (*Philosophische Studien*) for the publication of experimental investigations. Voluminous publications on many aspects of psychology represent the further contribution of this pioneer in the field of experimental psychology. Wundt's influence was exercised not only in this systematization of psychology, but in giving direction to the work of students who flocked to him. The men who were to be leaders in the development of psychology in Germany, England, France, and the United States came to Wundt in Leipzig, and carried back methods and points of view which have influenced the develop-

[2] G. Murphy, *An Historical Introduction to Modern Psychology*, New York, 1929, p. 160, also p. 173.

[3] W. B. Pillsbury, *The History of Psychology*, New York, 1929, p. 130.

ment of industrial as well as other specialized fields of psychology.

The introduction of experimental method into the study of human conduct was a necessary preliminary to the application of psychology in industry. However, the actual expansion of psychology as an applied science involved further changes within the science, most particularly modifications in viewpoint with respect to the scope and purposes of the new science and in the acceptance of techniques not employed in the early days of experimental psychology. The changes in the science which are of particular significance from the viewpoint of the industrial psychologist are:

1. *The extension of its boundaries to include the study of individual differences.*

2. *The enlargement of the scope of psychology to include its application in promoting individual adjustment.*

THE STUDY OF INDIVIDUAL DIFFERENCES

In its early phases experimental psychology was concerned solely with the formulation, on a factual basis, of principles and theories of human behavior. Wundt's work on the psychology and physiology of the senses, his interest in association experiments, his concern with the relation between the physical and psychical worlds are all outgrowths of an endeavor to verify psychological principles of wide application. So, for example, in the study of reaction time his interest was centered on the effect of the stimulus—the time of response of visual in contrast with tactual and auditory stimuli, on the influence upon reaction time of such complicating conditions as the association of ideas and of other complex mental phenomena, etc. He was interested in these measurements primarily because they furnished an opportunity for the analysis of the mental processes that precede the action. The analysis of the processes led to an emphasis on *introspection*—a controlled self-examination by the subject of the contents of consciousness—as the chief experimental technique of psychology. The actual data on reaction time, as well as those obtained in other experiments, were considered of significance only as they helped in the formulation of general principles with respect to functions of the human mind. The responses of the few subjects included in the experiment were considered valuable to the extent that they could be looked upon as representative of all persons. Viewed as examples of the responses of the *individual,* as typical of *his* behavior, they had no significance. "In the Wundtian school individual differences were wiped out in averages or completely ignored in an effort to get at generalizations about the elemental contents of consciousness in analogy with the study of atoms and forces in chemistry and physics. Introspection, in the form of verbal report, was simply an aid to the arrival at more adequate statement of laws. If the individual was thought of at all by the Wundtians it was in the

analogy of the 'economic man' of classical political economy, a psychologic man or automaton built up in additive fashion, from the elements and attributes of consciousness." [4]

Industrial psychology is interested in the individual—in his reactions in a specific situation. The growth of industrial psychology has been associated with the development of a psychology interested not primarily in general tendencies, but in the problems of a single individual and in the nature and extent of the variation of his response from the reactions of other individuals.

"This individual constitutes, as it were, the raw material of the discipline; it is he that is to be trained, educated, controlled, and made efficient. It is he that must be tested, measured and compared" [5] and with whose general adjustment and efficiency industrial psychology is concerned. The inability of a single individual to discriminate between green and red is of no significance to the exponent of Wundtian psychology, inasmuch as the investigator is interested primarily in the analysis of the factors underlying color discrimination, and in the amount of difference which must exist between two stimuli to permit discrimination by the "typical" individual. To the industrial psychologist this peculiar variation from other individuals is of enormous significance, particularly if the selection of a worker for the transportation industry is involved.

Industrial psychology is based upon a study of *individual differences* —of human variability—the importance of which as an objective of scientific psychology seems to have first been definitely recognized and stressed by Sir Francis Galton, who was the "pioneer of an experimental psychology that was primarily, though not entirely, concerned with the problem of human individual differences." [6] A paper published in 1879 led the way in the study of individual differences.[7] His *Inquiries Into Human Faculty and Its Development*, published in 1883, represents the first major contribution toward a scientific individual psychology. Galton was interested in a survey of available human assets, and undertook to use *tests* for the study of human differences. In examining these differences he was primarily interested in performance and not in the detailed physiological or conscious conditions that lie back of the performance.

Galton's first contribution to the study of individual differences was a statement of the problem. In addition, he insisted upon an adequate sampling of the human population as a means of determining the character and range of individual differences. He first conceived the idea of applying to the study of individuals the *normal law of error* [8] de-

[4] K. Young, "The History of Mental Testing," *Ped. Sem.*, 31 (1924), p. 44.
[5] H. P. Weld, *Psychology as Science*, New York, 1928, p. 270.
[6] E. G. Boring, *History of Experimental Psychology*, New York, (1929), pp. 472–474.
[7] F. Galton, "Psychometric Experiments," *Brain*, 2 (1879), pp. 149–62.
[8] See Chapters VI and VII for a discussion of these concepts.

veloped by Quetelet, and thereby helped to promote the universal application of the *Gaussian Curve.*[8] It was Galton who first worked out the method of *correlation*,[8] so important a technique in psychological investigation, and applied it in the study of relationships between human traits. His study of individual differences in imagery, by the use of the *breakfast table* questionnaire, employing the method of introspection, remains a classic experiment in this field. In addition, he is responsible for the invention of a number of *mental tests*, some of which are still in use in psychological laboratories and clinics.

There seems little doubt that the first important work in the experimental study of individual differences and in the use of tests and statistical methods for their analysis was done by Galton. It is equally true that the remarkable development during the last four decades of the study of the individual as a part of the science of psychology, in the United States at least, and to some extent throughout the world, is largely due to the initiative and energy of J. McKeen Cattell. In the "nineties" the field of individual differences, which had been originally explored by Galton, became, through Cattell, a prominent part of experimental psychology. "Cattell was Wundt's first assistant, self-appointed with genuine American intrepidity. Wundt states that Cattell simply came to him and said, 'Herr Professor, you need an assistant and I will be your assistant'! . . . Cattell brought to Wundt, accustomed to assigning problems arbitrarily to students, his own problem, the problem of individual differences, and succeeded in working upon it, for all that Wundt called it '*Ganz Amerikanisch*'—as indeed the problem has turned out to be." [9]

Cattell started by working on orthodox problems of Wundtian psychology—problems of association, of reaction time, problems in the field of *psychophysics*. To these he brought not only a thorough knowledge of the principles and techniques of the "old psychology," but a highly critical sense in the formulation of new methods for the study of older problems. In addition, he became a pioneer in the exploration of other fields of research, such as the time of perception of reading, the range of attention, the legibility of letters of the alphabet, which until then had received no attention. To his other qualities he added a facility for developing and defending the use of new statistical methods in the treatment of psychophysical and other data. Above all, he combined with the interest in "conventional procedures of psychology" an altogether "unconventional" concern about the individual.[10]

Cattell, says Thorndike, "was perhaps the first rebel from within the ranks of psychologists to set his face against the narrowness of the Wundtian school where individual diversities were hidden in averages

[8] See Chapters VI and VII for a discussion of these concepts.
[9] E. G. Boring, *op. cit.*, p. 391.
[10] G. Murphy, *op. cit.*, p. 177.

or even discarded as erroneous." [11] Whether Cattell's interest in individual differences reflects the opinions of Galton, or whether it developed independently in the fertile ground of Cattell's mind, cannot be definitely known. Apparently his tendency to pass beyond the formulation of general rules and to define quantitatively the nature and significance of individual differences was present when Cattell became Wundt's self-appointed assistant in 1883, and possibly when he first came to Leipzig in 1880. It is significant to note that Cattell did not meet Galton until after his departure from Leipzig in 1886. In a paper published in 1885 [12] there is already a recognition of the importance of individual differences, and in another, published in the same year, he is bold enough to declare, with reference to reaction time, that "the individual difference is a matter of special interest." [13] This interest thrived in Leipzig, in spite of, or possibly by reason of, the orthodox surroundings. It matured during Cattell's incumbency of the first professorship of psychology in the world, at the University of Pennsylvania (1888–1891). In 1890 he published a notable paper on "Mental Tests and Measurements" [14] setting forth in detail his position on the measurement of individual differences, describing 10 tests which he was using, and recommending the use of "mental tests" as apparatus in psychological experimentation. His insistence upon the use of statistical methods for the measurement of variation from the central tendency, to supplement the examination of the central tendency, appears in this and other articles.

Cattell's first elaborate exploration of individual differences was undertaken in 1894, after he had been called to Columbia University, and involved the use of a battery of tests in measuring the physical and mental status of Columbia students. This study, published in collaboration with L. Farrand in 1896,[15] is the first of its kind. Cattell not only initiated the mental testing movement for the measurement of individual differences in the United States, and stimulated its growth in other countries, but he has also remained a force in the development of this movement. The history of industrial psychology shows Cattell in the vanguard of those who recognize the importance of individual differences in accounting for variability in performance on the job, and who recommend the mental test, the tool used in the measurement of individual differences, as an aid to the promotion of individual adjustment and efficiency in industry.

Another chapter will be devoted to a discussion of the findings of

[11] Cited from K. Young, *op. cit.*, p. 32.

[12] J. McK. Cattell, Über die Zeit der Erkennung und Bennenung von Schriftzeichen, Bildern und Farben," *Phil. Studien,* 2 (1885), pp. 635–50.

[13] J. McK. Cattell, "Über die Trägheit der Netzhaut und der Sehcentrum," *Phil. Studien,* 3 (1885), pp. 94–127.

[14] J. McK. Cattell, "Mental Tests and Measurements," *Mind,* 1 (1890), pp. 373–80.

[15] J. McK. Cattell and L. Farrand, "Physical and Mental Measurements of the Students of Columbia University," *Psych. Rev.,* 3 (1896), pp. 618–48.

Cattell and of investigators since the time of Cattell upon the nature, distribution, and origin of individual differences. It is not within the scope of this book to trace further the early influences in turning psychology away from a limited study of the processes of the human mind, by the method of introspection, to the broader study of differences by objective methods. The names of Kraepelin and Münsterberg in Germany, of Binet in France, would necessarily enter into such a discussion. It is also unnecessary to describe the rapid rise and far reaching developments in the use of mental tests in education, in psychological clinics, and in other situations during the first quarter of the century. This discussion of the work of Galton and of Cattell is sufficient to show the nature of one important change in the science of psychology which has been extremely significant in the growth of industrial psychology.

THE APPLICATION OF PSYCHOLOGY IN PROMOTING INDIVIDUAL ADJUSTMENT

Another change which has been equally important in the development of industrial psychology is the expansion of psychology to include the application of its findings in promoting individual adjustment. Conceived as a "pure" science, unbesmirched by an ulterior or practical objective, psychology has been drawn into the maelstrom of life outside the sheltered laboratory. The interest in "pure" sensation has been supplemented by a concern for the mental traits of those euphemistically designated by the mid-Victorians and the clergy as the "impure." The measurement of visual perception of distance of selected observers, trained in the method of introspection, has been extended to the determination of visual discrimination of distance by applicants for the position of motor vehicle operator. The statistical methods of traditional psychophysics, originally reserved for the treatment of sense data, has been extended to the evaluation of human attitudes toward such highly mundane activities as war and birth control. Psychology, just as the older and possibly more "respectable" sciences of physics and chemistry, has rapidly become a servant of the arts and crafts, the boon companion of technical procedures in such varied fields as education, politics, and industry. So rapidly and thoroughly has psychology become "practical" and "applied" that there remain but few psychologists whose interests have not at one time or another impinged upon activities outside the laboratory, who have not been drawn into studies outside of the revered and circumscribed field of "pure" science, or whose investigations have not at least been found to apply to the solution of problems of human adjustment in one field or another. So universal is this trend, that it may almost be said that in psychology nothing remains "pure," in spite of the painstaking distinctions between "pure" and "applied" psychology so care-

fully drawn by Weld [16] and Boring,[17] to which reference will be made at the end of this chapter.

In the application of psychology there has been a tendency to view it only *teleologically,* i. e., with respect to the situation in which it is applied. So, for example, it has been oriented as psychology in education, psychology in industry, psychology in politics, etc. Viewed from this perspective, there has been an inclination to overlook the common factor present in the application of psychology regardless of the field in which it is applied. This common factor is the *individual* whose adjustment to the situation in which he is functioning must be the chief concern of an "applied" psychology. This tendency to overlook the individual was, of course, characteristic of Galton's work and has been particularly prominent in American psychology, where the statistical treatment of mass data on individual differences in specific mental traits and responses has until very recently been in the ascendancy. The individual, represented by an impersonal score on one or another test, has often been completely lost in the shuffle of interpreting mass data in terms of the aim for which they were gathered.

Within recent years this tendency has become less pronounced, replaced by a viewpoint which emphasizes with renewed vigor the "unity of the organism" as the basis of study.[18] In the application of psychology in education, in industry, and elsewhere, there has been a pronounced shift away from the statistical treatment of mass data to the complete study of the characteristic mental traits and patterns of behavior of the *individual* as an aid in *his* adjustment. The early students of individual differences were particularly concerned with highly specific human traits and responses in which differences existed, and in the extent and nature of such variations in the human race. Psychologists to-day are increasingly interested in differences between individuals considered as total entities, as "personalities," and in the influence of such "total personality" differences upon individual adjustment. The psychologist now concerns himself with the distribution and pattern of varied traits and responses in the single individual—with *trait differences*—as well as with the variability of a single trait in numerous individuals.

"The fundamental fact of applied psychology is that the individual is the unit of action, and all advance in this science must rest upon a knowledge of the laws of individual behavior, and the conditions which affect it. To one who reviews the field of modern business, industry, and education, the striking thing is the emphasis that is being placed on the individual rather than the group. It can be seen in education in the recognition of the fact that the individual should be the

[16] H. P. Weld, *op. cit.*, p. 297.
[17] E. G. Boring, *op. cit.*, p. 699.
[18] K. Young, *op. cit.*, p. 46.

real unit rather than the class, although actual practice is limited to an approximation of this ideal. It can be seen in industry in the use of the piece work system and reward system, which base pay on what the individual can do; the consideration of the individual in the construction of machinery; the arrangement of hours of labor, rest, vacations; the consideration of the individual in the selection and training of employees." [19]

THE CONTRIBUTION OF CLINICAL PSYCHOLOGY

The complete study of the individual from the viewpoint of his adaptability in diverse situations has been the particular province of *clinical psychology,* which naturally draws upon the findings of laboratory investigations and upon principles developed as a result of the statistical treatment of mass data. The study of the total individual for purposes of adjustment found its earliest exponents in France, where psychology grew up in close association with medicine. "The French psychologists have tended on the whole to study the individual's reactions with a view to understanding the total adjustment of the organism of personality." [20] A review of French psychology would lead us back, perhaps, to Pinel and Itard.[21] The latter's attempt to rehabilitate a wild boy found in the forests of Aveyron, in Southern France, is the first attempt at a studied rehabilitation of a defective personality. The trend is reflected in the work of Seguin,[22] the first exponent of the scientific therapeutic treatment of the feeble-minded, whose influence is realistically reflected in the many institutions and training schools for the feeble-minded found today in every civilized country of the world. The complete story would necessarily include the name of Charcot, sometimes called the "father of systematic French clinical psychology," the first to publish observations on imaginal types, whose thoughts and findings in the study of psychopathological personalities have influenced the work of many students of normal and abnormal behavior today; and of Ribot, largely responsible for the advent of the new scientific psychology in France. In Binet, whose interest in the measurement of intelligence grew out of a desire to separate the feeble-minded from the normal school children in Paris, is found again the concern for individual adjustment which has been referred to as characteristic of the French exponents of psychology. Finally, the trend still exists in the important contributions of Janet,

[19] A. T. Poffenberger, *Applied Psychology,* New York, 1927, p. 16.

[20] E. G. Boring, *op. cit.,* p. 665.

[21] J. M. G. Itard, *An Historical Account of the Discovery and Education of a Savage Man or of the First Developments, Physical and Moral, of the Young Savage Caught in the Woods near Aveyron, in the year 1789,* London, 1802. See also J. M. G. Itard (Translated by G. and M. Humphrey), *The Wild Boy of Aveyron,* New York, 1932, pp. 104.

[22] E. Seguin, *Idiocy and Its Treatment by the Physiological Method,* New York, 1907.

"the dean of psycho-pathology in France, whose work takes on a wider significance as the line between the normal and the abnormal, especially in hysterical phenomena, becomes obliterated with the advanced study of the normal personality."[28]

Although the French were the earliest exponents of the psychology of individual adjustment, the development of procedures for individual study and adjustment and the application of psychological findings for these purposes in the United States, at least, are largely due to the vision and initiative of an American psychologist, Lightner Witmer. When, in 1896, he founded, at the University of Pennsylvania, a *Psychological Clinic* in which complete studies of individual personality were made in promoting the normal adjustment of every child, he became a pioneer in the application of techniques which have gradually found their way into industry, as well as into other situations in which psychology has been applied. In this clinic medical and psychological studies were combined. Intelligence tests in the modern sense were not at first available, but as the number of tests has increased clinics are making wider use of these testing methods. A trained social worker may be called into service—a worker who employs standard rating scales and other devices for appraising the social environment of the individual—and brings to the clinician a detailed account of the family and its broader social influences, which often proves invaluable in the adjustment of the individual. Each of these factors is carefully considered and weighed in relation to each of the others. On the basis of such an evaluation a program is developed suitable for the particular individual. The facts so obtained and evaluated in terms of the problem of the single individual also serve an additional purpose. They contribute toward the psychologist's knowledge concerning the interplay of all factors which contribute to maladjustments and toward the formulation of psychological principles for the prevention of such maladjustments.

Similar procedures are followed by the clinical psychologist in the treatment and study of the maladjusted adult in industry. So, for example, the application of the procedures of clinical psychology has led to the complete study of individuals involved in accidents. The individual has been made the point of departure for a thorough examination of every factor—physical, mental, social, and economic—which may have played a part in the accident in which he has been involved. From such a clinical analysis it has been possible not only to assemble complete data on the causes of the accident, and to provide for the adjustment of the individual, but also to arrive at sound principles for the prevention of accidents in industry. In later chapters will be found further and more detailed illustrations of the use of clinical methods in in-

[28] G. Boring, *op. cit.*, p. 666.

dustry—of "the regard for the unity of the organism" which alone makes possible a complete adjustment of the individual in the industrial, as in other situations in life.

PSYCHOLOGY APPLIED VS APPLIED PSYCHOLOGY

These are the forces within the science of psychology itself which have been of particular significance in making possible an industrial psychology. Numerous contributory factors have been omitted from this discussion. Among these are the shifting emphasis from "mind" to "performance" (reflected in the development of *behavioristic* psychology) and an insistence upon controlled observation of overt performance to supplement introspection of one's own mental processes. They include the growing concern for patterns of behavior (characteristic of *gestalt* psychology) to supplement the analytic study of mind by the *structural* psychologist, an increased regard for underlying physiological processes, etc. Laboratory findings on learning and fatigue have played a distinct part in the development of a psychology of work. The elaboration of refined statistical techniques for the treatment of psychological data by Pearson, Spearman, Thomson in England, and by Thorndike, Kelley, Toops, Thurstone, and others in the United States, has enormously facilitated the application of psychology in industry. Its growth has also been associated with the successful use of tests in other fields, and with the development of apparatus and procedures in laboratory work on problems of "pure" science.

The detailed history of industrial psychology will be treated in the next chapter. In the present discussion of the psychological foundations there still remains the problem of indicating the relationship between industrial psychology and the science of psychology in general. On the question of relationship there has been much discussion among psychologists, not only with reference to industrial psychology, but also with respect to other phases of applied psychology. The problem has been considered in some detail in a volume on *Psychology As Science* by Weld.[24] The goal of "critical" science, according to this author, "is the acquisition of knowledge for its own sake and not for the practical use of mankind." This definition definitely places industrial psychology, and, as a matter of fact, every kind of applied psychology, outside the realm of the science of psychology. Applied psychology may employ the theory, the procedures, and the facts of pure psychology. It may even make a return to pure psychology in the form of problems which, when investigated, enlarge its range of knowledge, but the practical objective of applied psychology sets it apart from the science of psychology.[25] This separation is further widened by the dependence of applied psychology upon sources other than psychology

[24] H. P. Weld, *op. cit.*, p. 17.
[25] *Ibid.*, p. 85.

for knowledge that may be of service in attaining its practical needs or objectives. The term *psychotechnology* is employed to describe the combination of the procedures and objectives of applied psychology with its body of theory drawn from empirical psychology.[26]

Psychotechnology, according to Bingham, is "the offspring from the union of psychology and practical affairs." [27] It is not a special kind of psychology with procedures, theories, techniques different from those of pure psychology. Moreover, it is not identical with pure psychology. "The two are related in much the same way that any of the numerous science-technology teams are related, such as botany and agriculture, physics and mechanical engineering, astronomy and navigation. A science is an organized body of knowledge, facts, principles, laws. A technology is a more or less loosely related assortment of scientifically tested rules for accomplishing certain practical ends. So with pure psychology and applied psychology. As a pure science, psychology is not concerned with practical utility, but merely with increasing, verifying, and organizing our knowledge about mental life or behavior. Psychotechnology, or applied psychology, is interested in acquiring facts and principles only in so far as they can be turned directly to account in the solution of practical problems, in industry, selling, teaching, or other fields of human endeavor." [28]

There have been varied objections to this distinction between psychology and psychotechnology. So, for example, Freyd [29] condemns the distinction on the ground that the method, content, and control of the two are similar, and that science should be defined in terms of these factors rather than in terms of goals. This critic presents as an additional argument for his point of view the fact that confusion with pseudo-science may result from the separation of applied from pure psychology. The controversy is somewhat beclouded by quibbling over terminology. It is characterized by arbitrary distinctions. It is complicated, particularly in the case of experiments performed in the laboratory, by difficulties in distinguishing between investigations motivated by a search for increased knowledge and those having a utilitarian objective.

[26] The term psychotechnology has come to be used very widely as synonymous with applied psychology. The Germans have adopted the term *psychotechnik* as a synonym for psychotechnology. However, the latter term has also been frequently, although mistakenly, employed to designate the specific application of psychology in industry. As a matter of fact, *industrielle psychotechnik* is the phrase to be used in describing the application of psychology in industry just as in this country the term *industrial psychology* is used to distinguish a branch of psychotechnology, differing in scope or application from that of educational psychology, criminal psychology, etc. It is, incidentally, interesting to note that the term *Arbeitswissenschaft* (science of work) is used by Lippman and others to designate the concentration of knowledge and method from diverse fields upon the problems of work.

[27] W. V. Bingham, "On the Possibility of an Applied Psychology," *Psych. Review,* 30 (1930), pp. 289–305.

[28] F. A. Kingsbury, *Applying Psychology to Business, Annals of the Amer. Acad. of Pol. and Soc. Science,* 110 (1923), pp. 2–12.

[29] M. Freyd, "What Is Applied Psychology?" *Psych. Review,* 33 (1926), pp. 308–314.

In one respect at least the emphasis upon psychotechnology as contrasted with psychology has been harmful. It has helped to complicate the problem of setting up and enforcing standards with respect to those who should conduct psychological investigations in industry. Both in the United States and abroad, perhaps most particularly in Germany, there has been a tendency for the study of human behavior in industry to slip from the hands of trained psychologists into those of inadequately trained "technicians." In the insistence upon the specialized character of industrial psychology there has been a tendency to forget that the practitioner in industry must first be a psychologist before he can be an industrial psychologist, or a psychotechnologist. It is true that the problems with which the latter works must be investigated in industrial situations, but they can only be solved by workers carefully trained in the science of psychology—as the physician is in the science of biology, the engineer is in the science of physics.

This discussion of the psychological foundations of industrial psychology shows the latter to be the product of many forces. These forces account for the objectivity of its approach, and for the specialized techniques, the scientific curiosity, and the analytic interpretation of observed data which are characteristic of industrial psychology. They also explain its viewpoint, which "is scientific, empirical, critical. It is not content to evolve a beautiful theory in the seclusion of the study and adopt it as a final explanation. It insists that theories must be put to practical test. It witholds judgment until evidence is in, and accepts nothing on mere hearsay or judgment." [80] With this insistence upon the scientific criteria employed in laboratory investigations is combined a desire to learn the precise causes of behavior for the purpose of predicting and controlling human behavior in industry. The pioneers in industrial psychology are, after all, in most instances, just "plain" laboratory psychologists who started with an undirected thirst for knowledge and ended with an interest in improving the status of their fellow-men in industry.

They perhaps believe that "the final test of the value of what is called science is its applicability." [81] They recall that "the practical needs of the astronomer to eliminate the personal equation from his observations led to the invention of the chronograph and the chronoscope, and that without these two instruments modern psychology and physiology could not have achieved the results of the last 50 years." As psychologists they recognize that "the pure and the applied sciences advance in a single front," and that "what retards the progress of one retards the progress of the other; what fosters one, fosters the other." [82] As investigators in the applied aspects of the science they

[80] F. A. Kingsbury, *op. cit.*, p. 6.
[81] L. Witmer, "Clinical Psychology," *Psych. Clin.*, 1 (1907), p. 3.
[82] *Ibid.*

contend that "in the final analysis the progress of psychology, as of every other science, will be determined by the value and amount of its contributions to the advancement of the human race." [38]

[38] *Ibid.*

V. THE RISE AND SCOPE OF INDUSTRIAL PSYCHOLOGY

In early scattered experiments in laboratories of psychology and physiology are found indications of interest in problems of work which later led into the elaborate program of modern industrial psychology. In the work of Marey [1] and Mosso [2] on bodily work and fatigue, before the turn of the century, in that of Ioteyko [3] and Imbert [4] and others, during the first decade of the century, is found a recognition of one of the major problems of industrial psychology. Moreover, in these investigations techniques were developed which have been found of value in the industrial situation. The study of learning curves by Kraepelin,[5] at the beginning of the century, laid a basis for the analysis of such curves as an aid in the selection and training of workers. Of equal significance from the viewpoint of training in industry are the investigations of Bryan and Harter [6] on progress in learning telegraphy and of Book [7] on psychological conditions in learning to operate a typewriter. An investigation to determine the psycho-physiological traits required for success in typewriting, started by Lahy [8] in 1905, represents a step in the direction of job analysis and vocational selection. Preliminary experiments on the selection of street car operators were undertaken by the same investigator [9] in 1908. The appearance in Germany, in 1907, of the *Zeitschrift für angewandte Psychologie,* edited by Otto Lipmann and William Stern, is another indication of the direction of the wind.

[1] J. E. Marey, *La Méthode graphique dans les Sciences experimentales,* Paris, 1878, also "Travail de l'homme dans les Professions manuelles," *Rev. de la Soc. Scient. d'Hyg.*, Paris, 1904.

[2] A. Mosso, *Über den Einfluss der Muskelarbeit auf den Gaswechsel beim Gehen des Menschen, Pflüg Arch,* 1888, 49.

[3] J. Ioteyko, *Entrainement et Fatigue au point de vue militaire,* Bruxelles, 1905. "Sur L'Équation générale des Courbes de Fatigue," *C. R. Acad. des sci. de Paris,* August 24, 1904.

[4] A. Imbert, "L'Étude scientifique experimentale du Travail Professionnel," *L'Année Psychologique,* 13 (1907), pp. 245–59.

[5] E. Kraepelin, "Die Arbeitskurve," *Phil. Stud.*, 19 (1902), pp. 459–507.

[6] N. Harter and W. L. Bryan, "Studies in the Physiology and Psychology of the Telegraphic Language," *Psych. Rev.*, 4 (1897), pp. 27–53.

[7] W. F. Book, *The Psychology of Skill,* University of Montana, 1908, pp. 211.

[8] J. M. Lahy, "Les Conditions psycho-physiologiques de l'aptitude au Travail dactylographique," *Journal de Physiol. et Pathol. gen.*, 1913, pp. 826–34.

[9] J. M. Lahy, "La Superiorité professionnelle chez les Conducteurs de Tramway dans ses Rapports avec la Consommation d'Énergie electrique," *La Technique Moderne,* 7 (1913), pp. 338 ff.

A volume by Scott,[10] published in 1911, represents a first essay in the application of the principles of psychology in inducing employees to increase the quantity and to improve the quality of their work; in recruiting employees; in selling by personal appeal, and in advertising. "The greatest business problems of our day," wrote Scott,[11] "have to do with the personnel of industry, and the arts of guiding and influencing men in the achievement of business aims. . . . The student who would like to learn the art of influencing men in business must begin with psychology, which is to this art what physics and chemistry are to engineering. . . . It is the only science," he adds, "that can give us any sound information about human nature." With these as his premises, Scott undertakes to add to the material incentives recognized in the Taylor system a list of less tangible but equally potent non-financial incentives which make men work. This volume represents the first studied analysis of workers' motives by one trained in the theories and procedures of psychology.

THE CONTRIBUTION OF HUGO MÜNSTERBERG

In spite of these earlier indications of an interest in men at work, the problems and program of an industrial psychology were first systematically formulated by Hugo Münsterberg, a German psychologist, who, during the last years of his life, served as director of the Psychological Laboratory at Harvard University. Münsterberg was a product of the Leipzig laboratory. Like Cattell he became dissatisfied very early with the orthodox experiments of the Wundtian school and developed an interest in the study of individual differences.[12] With this he combined a desire to put the findings of the psychological laboratory to practical use. In a popular volume entitled *On the Witness Stand* [13] he described the application of psychological principles in the detection of crime. In another volume, *Psychology and the Teacher*,[14] he compiled the psychological facts and principles useful in the class-room situation. Investigations in industry and a program for industrial psychology were first described by Münsterberg during 1910–11 when lecturing as an exchange professor at the University of Berlin. The program was developed in detail in a volume [15] published in Germany in 1912 and in an American volume published during the following year.[16] A further development of his points of view is found in a third text, *Grundzüge der Psychotechnik*, which appeared in 1914.

[10] W. D. Scott, *Influencing Men in Business*, New York, 1911, pp. 186.
[11] *Ibid.*, pp. 4–5, with D. T. Howard.
[12] H. Münsterberg, "Zur Individual Psychologie," *Zentralblatt für Nervenheilkunde und Psychiatrie*, 14 (1891), pp. 196–98.
[13] H. Münsterberg, *On the Witness Stand*, New York, 1908, pp. 269.
[14] H. Münsterberg, *Psychology and the Teacher*, New York, 1909, pp. 320.
[15] H. Münsterberg, *Psychologie und Wirtschaftsleben*, Leipzig, 1912.
[16] H. Münsterberg, *Psychology and Industrial Efficiency*, Cambridge, 1913, pp. 320.

Münsterberg pointed out the importance of psychology in promoting the adjustment and efficiency of the worker in the industrial situation. He indicated that in industry the psychologist can serve, first, by finding the men whose mental qualities make them best fitted for the work which they have to do; secondly, by determining the psychological conditions under which the greatest and most satisfactory output can be obtained from every man; and, in the third place, by producing most completely the influences on human minds which are desired in the interest of business. For the attainment of these objectives Münsterberg outlined definite proposals involving the use of tests in the selection of workers; the application of findings on learning in training industrial personnel; the study by psychological techniques of conditions of work, the motives of workers, factors producing fatigue, etc. He not only outlined the program, but cited results from his own investigations on the selection of motormen, telephone operators, and ship's officers to indicate the practicability of the methods which he recommended and the character of the results to be obtained from their application.

In developing his program, Münsterberg related it to Taylor's proposals for scientific management and stressed the dependence of economic production in the factory upon the efficient use of its man power. Münsterberg did not neglect the social implications of the program which he had outlined. "We must not forget," he writes, "that the increase of industrial efficiency by future psychological adaptation and by improvement of the psychophysical conditions is not only in the interest of the employers, but still more of the employees; their working time can be reduced, their wages increased, their level of life raised. And above all, still more important than the naked commercial profit on both sides, is the cultural gain which will come to the total economic life of the nation, as soon as every one can be brought to the place where his best energies may be unfolded and his greatest personal satisfaction secured. The economic experimental psychology offers no more inspiring idea than this adjustment of work and psyche by which mental dissatisfaction in the work, mental depression and discouragement, may be replaced in our social community by overflowing joy and perfect inner harmony." [17]

The publication of Münsterberg's program served as a stimulus for the initiation of investigations in the field of industrial psychology, both in the United States and Europe. It was from Europe, from the halls of the University of Leipzig, and from the mind of Wilhelm Wundt that the United States received its first impulse for an experimental psychology. In the New World a German psychologist, reacting to the stimulating forces of his environment, transformed this impulse and returned it to Europe in the form of a program for a newer application of the principles and theories which he had brought with him

[17] *Ibid.*, p. 308.

from the Old World. Europe, as well as America, recognizes Münsterberg as the founder of applied psychology in industry.

The development of industrial psychology since the time of Münsterberg, who died in 1916, will be sketched only in broad outline, since many of the important investigations will be described in detail in the chapters which follow. This sketch will give a general picture of the major trends in the rise of industrial psychology as an aid in the evaluation and interpretation of more recent developments. Its rise can best be described separately for each of the countries which have made contributions in this field. Before proceeding to this description along national lines, however, it seems well to refer to one common influence, that of the World War, which affected the growth of industrial psychology throughout the entire world.

THE EFFECT OF THE WORLD WAR

Münsterberg's formulation of the program of industrial psychology appeared shortly before the opening of the World War. The impulse toward this new application, created by Münsterberg, gained strength from the successful use of psychology in the selection and classification of army personnel by almost every nation engaged in the war. In England, for example,[18] laboratory psychologists were called upon to devise and administer tests for aviation pilots,[19] aeronautical observers, hydrophone operators, submarine "listeners-in," and for many other military and naval tasks requiring special capacities. In Germany and France tests were also developed to aid in the assignment of men to range-finding, motor vehicle operation,[20] airplane observation [21] and piloting,[22] and other specialized branches of the service.

The entry of the United States into the war in 1917 brought with it the largest scale experiment in the use of psychological methods that has ever been attempted. Recommendations made by a Committee of the Psychological Association for the use of tests and allied psychological techniques in the classification of personnel were accepted by Army authorities.[23] As a result, there were developed the well-known Army group tests, the Alpha for literates and the Beta for illiterates, applied to nearly two million men in the course of our participation in the

[18] *Tests of Educable Capacity*, London, 1924, p. 50.

[19] H. G. Anderson, "The Selection of Candidates for the Air Service," *Reports of the British Medical Society*, 3 (1918), p. 11.

[20] W. Moedc, "Kraftfahrer-Eignungsprüfungen beim Deutchen Heer," 1915 bis 1918, *Ind. Psychot.*, 3 (1926), pp. 23–28.

[21] K. Benary, "Bericht über Arbeiten zu Eignungsprüfungen für Fliegerbeobachter," *Z. Ang. Psy.*, 15 (1919), pp. 164–92.

[22] A. Gemelli, "Sull applicazione dei metodi psico-fisici all esame dei candidate all avviazione militare," *R. Ps.*, 1917, 13, 8, pp. 2–3.

[23] *The Personnel System of the United States Army* (official report), Washington, D. C., 1919. W. V. Bingham, "Army Personnel Work," *J. App. Psychol.*, 3 (1919), pp. 1–12.

war.[24] Moreover, in the United States,[25] as in European countries, investigations were conducted in the development of specialized tests for aviation [26] and for other technical services. Such tests included not only measures of capacity, but a series of trade tests [27] for measuring the proficiency of men considered for assignment to such skilled trades as carpentry, electrical work, tailoring, and to such semi-skilled occupations as chauffeuring, etc.

At the same time, during the period of the war, in many countries involved in the war, and in others, experiments on scientific selection for specialized occupations and on conditions of work were being carried on in civil life. The most significant developments in the rise of industrial psychology in each of these countries are indicated in the section which follows.

THE RISE OF INDUSTRIAL PSYCHOLOGY IN THE UNITED STATES

In the United States the growth of industrial psychology is largely the product of teachers and research workers attached to universities who have found in industry a laboratory as productive as the cloistered quarters of university halls. Scott, now president of Northwestern, Yoakum of Chicago, Poffenberger of Columbia, Burtt of Ohio State, Kornhauser of Chicago, and Moss of George Washington University, may be cited in illustration of this fact. Bingham, a pioneer in the application of psychology in industry, started his work as a member of a university staff and has maintained through summer schools his connection with universities. It may fairly be said that the major accomplishments and the most important contributions have come from psychologists attached to universities who have specialized in industrial research. Unlike the engineer, the doctor, the pharmacist, and other technological practitioners, the industrial psychologist in the United States has tended to retain his university affiliations, possibly as a source of support or of inspiration, when undertaking practical research in industry.

To these research workers in university centers has been added a select circle of industrial psychologists attached to individual industrial organizations and working exclusively upon the human problems of these organizations. Link, who is responsible for the first important major investigation and text on employment psychology,[28] Shellow of The Milwaukee Electric Railway and Light Company and Pond of the Scoville Works are examples of industrial psychologists who are

working or have worked exclusively in laboratories established in the plants of individual firms. Industrial psychology in the United States, unlike that in Europe, has not been institutionalized. For this reason the story of its rise can be told in the description of the work of independent investigators which appears in chapters which follow.

In the United States early experiments in the application of psychology in industry were limited to the development of selection techniques. Studies on tests for telephone operators by McComas [29] (1914), for telegraphers by Jones [30] (1915), the study of the interview as an aid in the selection of salesmen by Scott [31] (1915), an investigation on tests for typists and stenographers by Rogers [32] (1917), mark the beginnings of industrial psychology in this country. The growth in subsequent years took the form of an extension of the use of psychological tests and other objective techniques in selection for various occupations, and of an enrichment of the content and methods of industrial psychology by investigations in the field of training, accident reduction, monotony, the analysis of methods of work, etc. However, the bulk of work in the United States has been done in the field of vocational selection.

Progress in industrial psychology in the United States has been marked by the publication of a number of new journals. In the *Journal of Applied Psychology,* established in 1917, have appeared many articles describing psychological studies in industry. In 1922 appeared the *Journal of Personnel Research* (now the *Personnel Journal*), the organ of the Personnel Research Federation, edited by Bingham, and devoted primarily to articles dealing with industrial personnel problems. *Industrial Psychology,* a journal for the less technical description of psychological investigations, was started by Laird, of Colgate University, in 1926, but ceased publication in 1928. Moreover, starting with a volume on *Vocational Psychology* by Hollingworth,[33] published in 1916, and with Hollingworth and Poffenberger's *Applied Psychology,*[34] published in 1917, an increasing number of texts [35] on various

aspects of industrial psychology gives evidence of its rapid growth

Although the growth of industrial psychology in the United States has been largely the product of individual initiative, its development has been furthered by a few organizations established for co-operative research, for the co-ordination of studies, and for the exchange of information in this field. The earliest of these represent an outgrowth of a *Division of Applied Psychology* established in 1915 at the Carnegie Institute of Technology, under the direction of W. V. Bingham.[36] Within this division, later known as the *Division of Co-operative Research,* developed a number of different types of organizations for conducting research in co-operation with business concerns. *The Bureau of Salesmanship Research,* established in 1916 by 27 co-operating firms of national scope representing several types of industry, was among the constituent co-operative research bureaus. Under the title of the *Bureau of Personnel Research,* assumed after the war, and under the leadership of W. D. Scott and later of C. S. Yoakum, it contributed much in the form of original research in the field of salesmanship. Another outgrowth of this *Division of Applied Psychology* was a *Research Bureau for Retail Training,* established in 1917, which, under the direction of J. B. Miner and J. B. Charters, co-operated with a group of retail stores in the development of techniques for the selection and training of salespeople, service employees, and minor store executives. In addition, surveys were made for individual firms under the direction of the officers of the *Division of Co-operative Research.* In 1930 the *Research Bureau for Retail Training,* which in approximately 1922 changed its affiliations to the University of Pittsburgh, included 9 Pittsburgh members, 17 extension members, 8 members in the research and teaching staff, an office force, and 15 graduate students acting as research assistants.[37]

These research organizations, supported largely by industrial firms, but working under the aegis of the Carnegie Institute of Technology, made an important contribution to the development of industrial psychology, particularly in the field of sales and executive selection and training. Many of the men who were associated with the Division in its hey-day at the Carnegie Institute have maintained their interest in industrial psychology and have made important additions to its content and methods as independent investigators or as members of staffs of other universities.

The Psychological Corporation, organized in 1921, for the "advance-

ment of psychology and the promotion of useful applications of psychology"[88] represents another organization serving to promote industrial psychology. *The Psychological Corporation* is an association of psychologists who by the purchase of stock become members of the Corporation. The Corporation is intended to act as a clearing house between the general public and psychologists capable of rendering service in specialized fields. At the time of its organization it was not proposed that the Corporation make individual examinations, engage in industrial management or in research for individual firms. Industrial firms desiring to have psychological investigations are referred by the officers of the Corporation to existing laboratories and competent psychologists whose work can be recommended as scientific and sound. A proportion of the fees obtained by psychologists working upon investigations obtained through the *Psychological Corporation* is returned to the Corporation to pay its overhead costs. *The Psychological Corporation,* being a non-profit making organization, is expected to devote any surplus obtained in this way to research on basic problems in the field of applied psychology.

The Psychological Corporation has headquarters in New York, under the direction of Achilles, with Link and others as his co-workers. Individual psychologists are appointed as branch officers throughout the country. In its central headquarters the *Psychological Corporation* has been primarily active in conducting individual examinations for the purpose of vocational guidance and in promoting, in a general way, the application of psychology in guidance and in industry. More recently the central office has extended its activities to include the sale of testing material and investigations in the field of merchandizing.

Perhaps the most active of the organizations for the co-ordination of research is the *Personnel Research Federation,* organized in 1922 under the leadership of Bingham, through the co-operative efforts of the *National Research Council,* the *Engineering Foundation,* and the *American Federation of Labor.* It respresents a voluntary organization of executives, personnel workers, psychologists, and others interested in the scientific study of personnel problems in industry and in the school. It has conducted a few research investigations, the most notable of which is a study of accident-prone drivers.[89] However, the chief contribution of the Federation has been in promoting exchange of information among workers in the field and in making public, through the *Personnel Journal* and in its meetings, current research in the field of industrial psychology and of personnel adjustment.

Shortly after the war (1919) there was organized in Philadelphia

the *Scott Company*, a private organization specializing in the personnel problems of industry. Its work was discontinued in 1923. There have been two or three other attempts to set up private corporations for the promotion of psychological work in industry, but these, in some instances by reason of the unsound premise on which they were established, have been unsuccessful.

THE RISE OF INDUSTRIAL PSYCHOLOGY IN EUROPE

England

In England, the first systematic attack on the problems of human efficiency and welfare in industry developed out of the organization, in 1915, of a *Health of Munition Workers Committee* to find methods of increasing output and decreasing lost time and fatigue on the part of workers in industrial plants. This was replaced in 1918 by the *Industrial Fatigue Research Board* (later renamed the *Industrial Health Research Board*) established under the joint auspices of the *Department of Scientific Industrial Research* and the *Medical Research Council.*[40] It was the function of this government board "to undertake to promote better knowledge of the relation of hours of labor and other conditions of employment, including methods of work, functions of the human body, having regard both to the preservation of health among the workers and industrial efficiency; and to advise the Council upon the best means of securing the fullest application of the results of this research work to the needs of industry."

Financial support was withdrawn from the Board in 1921 but, in spite of the economic condition of the country, vigorous protest was raised in so many quarters that the Board was reinstated with a smaller staff directly under the supervision of the *Medical Research Council*. The activities of the *Industrial Fatigue Research Board* have been in the nature of broad surveys of such very diverse subjects as the comparison of different systems of shifts, the effect of rest pauses, the influence of atmospheric conditions, the analysis of individual differences in efficiency, time study, the investigation of causes of accidents, etc. These studies have been characterized by high qualities of workmanship in the form of careful experimental control supplemented by a very cautious interpretation of obtained data. The policy of the Board is to investigate general problems common to all industries rather than to study the needs and problems of a single firm.

In order to investigate problems for individual firms there was organized, in 1921, a *National Institute of Industrial Psychology*, under the leadership of C. S. Myers, the distinguished director of the Psychological Laboratory of Cambridge University. The work of this

[40] C. S. Myers, *Industrial Psychology in Great Britain*, London, 1925, pp. 11–18.

Institute is supported by grants from firms and from private individuals and, in part, by charges made to industrial firms in whose behalf investigations are undertaken. The object of the Institute is not only to carry on investigations at the request of individual industries, but to train and promote the training of investigators in industrial psychology throughout the country, and to promote basic research in this field. The National Institute has from time to time received grants from the *Carnegie United Kingdom Trust* and from other foundations as an aid in its work.

The investigations directed by the Institute, like those of the *Industrial Health Research Board,* have been diverse in character—ranging from the selection of workers for the dressmaking industry to the improvement of the lamps worn by miners in the coal regions of England. Further reference to these studies will be made in the body of this text. The investigations of the Institute, as well as other developments in the field of industrial psychology, are described in the *Journal of the National Institute of Industrial Psychology,* a publication started in 1922. (Recently renamed *The Human Factor.*)

An interesting feature of the work of the Board and of the Institute is the frequent (unofficial) interchange of investigators and joint investigation of problems.

The *National Institute of Industrial Psychology* has the support not only of industrialists throughout Great Britain, but that of the heads of psychological, physiological, and educational departments of universities throughout the country. Both the *Industrial Health Research Board* and the *National Institute of Industrial Psychology* are in the habit of "farming out" to university psychological laboratories problems which do not lend themselves readily to detailed factory investigations or upon which preliminary work must be done under the more standard conditions of the laboratory.

The work of these centralized bodies is supplemented to some extent by investigations conducted independently by university men. In addition, a few business firms have established psychological research departments of their own. However, in general, the rise and development of industrial psychology in Great Britain are very closely associated with the activities of the two organizations which have been described above.

Germany

In Germany, individual plants and public and private institutes have combined to expedite the growth of industrial psychology. Soon after Moede [41] and Piorkowski started their investigations on the selection of chauffeurs for the Army, in 1916, 14 centers were engaged in work upon this problem in Germany, some interested solely in civilian

[41] W. Moede, *op. cit.*

application. In 1917 a laboratory was established in Dresden by the Saxon Railway Company for the selection of locomotive engineers and of other employees. In the same year, under the direction of Heilandt,[42] The AEG (General Electric Company) of Germany undertook to use tests in the examination of machinists' apprentices. Early in 1918, the Greater Berlin Tramways began investigations on the selection of motormen and for years its psychological laboratory was among the best equipped and best organized in Germany.

After the war there came a renewed interest in the application of psychology in business which resulted in the establishment of numerous psychological institutes and in the organization of psychological laboratories by private firms. In July, 1922, 22 large concerns in Germany possessed their own psychological laboratories. In 1926 there were listed over 100 firms which were applying psychological methods in selection.[43] These included Krupp, Essen and Kiel; Carl Zeiss, Jena; Allgemeine Elektrizitätsgesellschaft, Berlin; Auerlichtgesellschaft; Osram-Werke, Siemens Company; Loewe Company; Greater Berlin Tramways; and others. Psychological laboratories, subventioned by the state, have been opened in connection with the administrative offices of the railways in Dresden, Frankfort, Mannheim, and Cologne, as well as in Berlin. In addition, in other governmental departments, such as the post office and telephone service, psychological research departments have been organized.

Institutes for the industrial application of psychology are to be found in all of the larger cities in Germany. The *Institut für Arbeitsphysiologie, Kaiser-Wilhelm-Gesellschaft,*[44] was established in 1916 in Berlin, for the express purpose of examining the physical and psycho-physiological factors affecting human performance in industry. Under the direction of Atzler it has become one of the leading research stations in the world for investigating energy consumption required for different kinds of work.[45] In 1918, the *Psychotechnical Institute of the Charlottenburg Technische Hochschule* was founded by Moede to collaborate with industrial establishments in the selection of employees. In the same year the Berlin *Institute for Applied Psychology* was amalgamated with the *Institute of Industrial Psychology,* established in 1916, and, under the direction of Lipmann, continues to promote research in every phase of industrial psychology. In 1919, Giese established in Halle an *Institute of Practical Psychology.* Among strictly private business organizations is the *Orga Institute,* established by Piorkowski, for the distribution and administration of industrial tests. In Munich, Dresden, Mannheim, Hamburg, Hanover, and else-

where are found other institutes. Some are attached to universities or technical schools; others are supported by the contributions of individual firms. All co-operate with industry, and even firms possessing their own psychological laboratories avail themselves of the services of these institutes. In addition, the psychological laboratories in universities are doing research work in the application of the science to commerce and industry.

Germany has a number of journals devoted to industrial psychology. The *Zeitschrift für angewandte Psychologie* continues to publish articles in this field. To this, in 1918, Lipmann and Stern added a supplement in the form of *Schriften zur Psychologie der Berufseignung und des Wirtschaftslebens*. In 1919, Moede started to publish *Praktische Psychologie,* replaced, in 1923, by *Industrielle Psychotechnik.* This was followed, in 1926, by the publication of *Psychotechnische Zeitschrift,* edited by Rupp.

From small beginnings has grown this enormous structure of research and application of psychology in selection, training, time study, motion study, the analysis of monotony, the study of fatigue, the effects of ventilation,—including investigations on every condition which may influence the happiness and production of workers. The economic motives have been in the ascendancy, particularly in the work of Moede and Piorkowski, but under the influence of Lipmann, Stern, and Rupp the responsibility for the welfare of the worker has not been overlooked.

Russia

In Russia, tremendous strides have been taken in the development of industrial psychology. The viewpoint underlying this progress was well expressed by Bechterew in an address delivered at the first pan-Russian Congress on the organization of work. "In a socialistic state the rationalization and scientific organization of work," he declared, "must be based upon the fundamental principle that the maximum of productive work can only be procured by fully protecting the health of the workers and by guaranteeing the complete development of their personalities." [46]

In 1920 there was established in Moscow, under the leadership of Gastev, a *Central Institute of Labor.* In 1927 this was one of more than 60 centers devoted to the scientific investigation of production and allied problems.[47] In 1931 the Central Institute alone was reported to have one thousand branches throughout Russia.[48]

The early work of this *Central Institute of Labor* was characterized

by a somewhat original approach.[49] Instead of undertaking to investigate a variety of problems, or to study one profession in its entirety, the Institute limited itself to a thorough analysis of two elements of work common to many occupations—the use of the hammer and the file. These operations were investigated in all their aspects in the seven laboratories constituting the Institute. Photographic studies were made of the movements involved in these operations. The tools were carefully studied. An investigation was made of the physiological changes and psychological effects of work with these tools. Scientific training systems were elaborated and, finally, studies made of the social factors influencing group activity on these operations. More recently the Institute has applied its specialized methods of analysis to bricklaying and the textile industry.

The Central Institute at Moscow has become much interested in the techniques of the Taylor System, and has tried to adapt them to increase production without entailing the harmful effects which followed an unwise administration of the system in the United States and elsewhere.[50]

Among the outstanding centers for the scientific study of work are the *Institute of Labor* in Charkow and the *Institute for the Scientific Organization of Work* in Kasan. Among the leading spirits in the promotion of this work are Spielrein, Hellerstein, and Kraval. Methods of work, conditions of work, fatigue, and similar problems at first engaged the attention of these, as well as of the Central Institute in Moscow. The primary concern with such problems, in contrast with those of selection, was evident at the first pan-Russian Congress on the organization of work in 1921 and at the one which followed in 1924.[51] At the same time consideration has been given to selection problems. As early as August, 1922, there was established in Moscow a *Laboratory of Industrial Psychology* which has undertaken investigations in the field of job analysis and vocational selection. Similar studies have been made in the applied branch of the *Neurological Institute of the University of Moscow*, and in other centers. The nature of developments in this field is perhaps illustrated in a report by Tramm,[52] following a visit to Russia in 1931, that in none of the German street railways is there a psychotechnical laboratory as large or as well fitted as that of the *Transport Technopsychological Institute* in Moscow. Twenty psychotechnicians, 15 doctors, and 80 government officials are employed in this institute which is governed by a council of: a.–trade union officials, b.–representatives of the railways, c.–representatives of the *Central Laboratory for Research into the Occupational Diseases of Railwaymen*. Twelve railroads have laboratories controlled by this institute.

[49] L. G. Walther, *op. cit.*, pp. 56, 57.
[50] G. W. Hartmann, *op. cit.*, pp. 352–54.
[51] W. Weber, *op. cit.*, p. 367.
[52] K. A. Tramm, *op. cit.*, p. 283.

The techniques employed here appear to be similar to those used in Germany and in the United States.

In general Russia has followed German and American influences, particularly in early investigations. However, more recently investigators have started to formulate theories and methods of their own, presumably better adapted to their problems. Interest in the work is reflected in the recent organization of an association of all Soviet Technopsychologists and in the publication since 1928 of a journal, *Technopsychology and Psychophysiology of Labor.*[53]

The Rise of Industrial Psychology in Other Countries

Only brief mention will be made of developments in industrial psychology in other countries. Practically none of the European or Asiatic countries have remained untouched by the surge of interest in the study of human work from the psychological point of view. "The problem of the worker is the order of the day in every country." [54] In Switzerland, Claparède and Bovet, of the Institut J. J. Rousseau, of Geneva, have long been active supporters of an industrial psychology. It was under their leadership that there was first convened in Geneva, in 1920, an international congress of applied psychology, devoted to a consideration of problems of vocational guidance and selection. From this institute appeared, in 1926, the first volume in French devoted specifically to the application of psychology in industry.[55] A psychotechnical institute, established in Zurich in 1922, under the direction of Suter, has occupied itself with selection for industrial and commercial establishments, training, and, to some extent, with the analysis of conditions of work.[56]

A section of the *Masaryk Academy of Labour,* an institute founded in Czecho-Slovakia in 1920 for the rationalization of methods of work, is given over to the investigation of psychological problems. Psychological laboratories have also been established by individual firms and by local communities.

In Holland, Belgium,[57] Poland, Italy, Spain, Austria, etc., the development of industrial psychology, both chronologically and from the standpoint of organization, has followed lines similar to those indicated in detail for Germany. In the main, the burden of promoting industrial psychology has been carried by institutes of applied psychology—psychotechnical institutes. In some instances they are completely sup-

[53] Anon., "Industrial Psychology in Russia," *J. Nat. Inst. Ind. Psy.*, 5 (1930), pp. 221–22.

[54] L. G. Walther, *op. cit.*, p. 60.

[55] L. G. Walther, *op. cit.*

[56] A. Carrard, "Organization scientifique du Travail au point de vue psychotechnique," *Memoires du Congres International de l'Organization Scientifique du Travail*, Bruxelles, 1925, p. 30.

[57] A. G. Christaens, "Vocational Guidance and Selection in Belgium," *Pers. J.*, 9 (1930), pp. 322–26.

ported by the government, in other instances by local communities, in still others by contributions from industrialists, labor unions, and from those they serve. In addition to the institutes there are psychological laboratories supported by individual firms—although they are few in number outside of Germany. On the secondary line are the university laboratories, working in most instances on basic problems generally applicable in the control of human behavior in industry.

The growth of industrial psychology is not limited to the Occident. In Japan agencies for the application of psychology in industry include semi-private agencies and governmental bureaus.[58] Among the former is an *Institute of Industrial Efficiency,* established in 1921. Psychological laboratories form part of the government telegraph and telephone departments. In a laboratory of applied psychology, attached to the Imperial University of Tokio, investigations are being conducted on selection for the Army and Navy, as well as on other problems of practical psychology.

INTERNATIONAL CONGRESSES

In this discussion of the rise of industrial psychology it is perhaps well to point to the development of an international clearing house for applied psychology which grew out of the meeting called in Geneva by Claparède and Bovet in 1920. This first international conference was followed by a *Second International Conference of Psychology Applied to Vocational Guidance and to the Scientific Organization of Work* in Barcelona in 1921. As the title of the conference indicates, industrial problems were given a definite place at this meeting. At a third conference, held in 1922 in Milan, the question of job analysis, the rôle of physiology and psychology in the prevention of accidents, and problems of Taylorism were discussed. These early conferences have led to the organization of an *International Congress of Psychotechnology* which, since 1924, has met in various European cities, the most recent meeting being held in Moscow in the fall of 1931. The increasing attendance at this congress, and the appearance of papers on industrial psychology at the tri-annual meetings of the *International Congress of Psychology* reflect the growing interest in this application of psychology.

SCOPE OF INDUSTRIAL PSYCHOLOGY

The application of psychology in industry involves inquiries into four kinds of relationships:[59]

[58] A. Yenjiro, "Angewandte Psychologie im Japan," *Psychot. Z.*, 2 (1927), pp. 29–33.
[59] W. V. Bingham, "Industrial Psychology, Proceedings of the 1928 Cambridge Congress of the International Industrial Relations Association," *Reprint and Circular Series,* Pers. Res. Fed., 15 (1928), pp. 27.

1. *Relations between the worker and his work.*
2. *Relations between the worker and his immediate supervisor.*
3. *Relations between the worker and management.*
4. *Relations between the worker and his fellow-workers.*

The objective of industrial psychology is to acquire better understanding and control of these relationships. The specific procedures employed in the attainment of this objective include:

1. *Study of the requirements of occupations.*
2. *Development and use of tests and other refined techniques in the scientific placement of workers.*
3. *Formulation of the best methods of applying human energy.*
4. *Organization and systematization of training programs to insure the most complete development and most efficient use of individual ability.*
5. *Determination of the optimal conditions of work.*
6. *Analysis of characteristics of industrial organization for the determination of types best adapted to serve both the economic and social, and broadly human objectives of industrial organization.*
7. *Examination and control of motivating forces, in the case of both workers and management, which influence harmonious relationships in the industrial situation.*

The field charted for exploration by industrial psychology is somewhat the same for all of the countries to which reference has been made in the preceding section. However, there are differences among them with respect to the sectors which have been selected for immediate exploration. These differences will be treated in somewhat greater detail in chapters which follow, but it may be well to summarize the general trends.

The application of psychology in the United States has been largely in the study of job requirements, in vocational selection, and in merchandizing. There are also occasional contributions in training, in measuring industrial fatigue, in studying workers' incentives, in determining best methods and best conditions of work, etc.[60] On the whole the latter applications have been considered in the field of the efficiency engineer. Enroachment upon this field has been frowned upon both by efficiency engineers and by psychologists.

Foreign psychologists, on the other hand, concern themselves more broadly with all factors which may influence the efficiency of man in industry. Foreign technical journals are filled with articles dealing with the responsibility and accomplishments of psychology in the field of motion study, the lay-out of equipment, the measurement of industrial

[60] M. S. Viteles, "Psychology in Business—in England, France and Germany," *Ann. Am. Acad. Pol. Soc Sci.*, 110 (1923), pp. 207–220. A. W. Kornhauser, "Industrial Psychology in England, Germany and the United States," *Pers. J.*, 8 (1929), pp. 421–434.

fatigue, etc. At the same time there are differences even among the European countries with respect to the attention which has been given to each of the procedures employed by industrial psychology. In England, at the time of the organization of the Industrial Fatigue Research Board and of the National Institute of Industrial Psychology, investigations were largely centered on the best methods of applying human energy, the determination of best conditions of work, and on studying the relations between management and labor. These have more recently been supplemented by an increasing number of studies in vocational selection. In Germany, on the other hand, the emphasis in the early days of industrial psychology was, as in the United States, on the development of selection tests, and Germany quickly became the leader in the extent of application of such tests. More recently, however, interests have become more catholic and there is an increasing number of reports on other problems. With the exchange of information and points of view among countries, and as more intimate relationships are established among investigators in different countries, there will probably develop a growing uniformity of interest and accomplishments in the diverse fields of activity of industrial psychology.

VI. THE NATURE AND DISTRIBUTION OF INDIVIDUAL DIFFERENCES

The application of psychology in industry is associated with an increasing knowledge of individual make-up. This knowledge has, in the main, been obtained from a comparison of many individuals to determine the nature and extent of resemblances and differences among them. Such investigations have furnished prolific data of extreme significance not only for industry, but for the school, the Church, and for other social institutions. Starting with the work of Galton and gaining impetus from the direct action of Cattell, the study of individual differences has, in the first place, centered the attention of the psychologist upon the significance of such differences, and secondly, has led to the formulation of general laws concerning the nature, range, and origin of such differences which are basic to the application of psychology in individual adjustment.

Numerous examples can be furnished of the ubiquity of individual differences. Many studies have shown that the dwarf and the giant are merely the extremes of a very wide range in physical stature. The layman's observation of differences between the idiot and the genius has been supplemented by many scientific studies on variability in intellectual capacity. The measurement of reaction time to the thousandth of a second has confirmed the distinction between individuals loosely described as "slow as molasses" and "fast as lightning" by their associates. The common recognition that certain individuals are "slow in learning" and others "fast in learning" is likewise substantiated by findings on wide differences in the rate of learning in random samplings of school children.

The existence of such differences has probably always been recognized.[1] "Wherever individuals come into close proximity it was inevitable that certain differences among them would be recognized." However, it is only within recent years that the traits involved have been precisely measured. Accurate measurement has revealed the magnitude of these differences and has also made possible a substitution of exact definitions and objective descriptions for the vague, unsubstantial, inaccurate concepts characteristic of the pre-scientific era in the study of human behavior.

The significance of individual differences in the application of psy-

chology in industry has been briefly referred to in Chapter IV. The science of industrial psychology is largely a study of the ways in which individuals differ, and a knowledge of the general principles of individual differences is essential for the comprehension of its diverse applications and findings. In the selection of workers, for example, the chief consideration is the variation among applicants in the capacity for performing the work for which choice is to be made. "The profits from

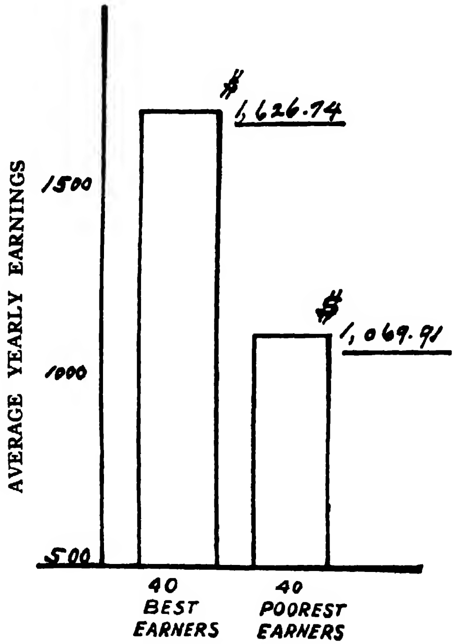


FIGURE 2. *Average Annual Earnings of Taxicab Drivers*

(From an Unpublished Study by the Author)

conducting an industry may be very materially affected by choosing the workers from one or another part of the distribution of the aptitude in question. In many industries the same amount of floor space, tools, machines, etc., are required by a man from the lowest 5 per cent as by a man from the highest 5 per cent of the distribution of the particular ability involved. Men chosen from the highest 5 per cent may produce from two to three times as much per unit of overhead cost as men from the opposite extreme of ability." [2]

An excellent example of this is to be found in the taxicab industry. Each driver is furnished a cab with a value of approximately $2000. The driver is allowed complete freedom with respect to the territory to

[2] C. L. Hull, *Aptitude Testing,* Yonkers, N. Y., 1928, p. 36.

be covered, etc. Every driver has at his disposal a centralized telephone system with which he can communicate from numerous "stands" scattered around the city. There is, in other words, a constant overhead expense which is the same for every driver regardless of the value of his gross receipts or net earnings. Supplied with uniform equipment and working under uniform conditions in the same territory, some drivers

YEARLY EARNINGS	40 BEST EARNERS NO.	%	40 POOREST EARNERS NO.	%
$ 900.–1000.			7	17.5
1000.–1100.			16	40.0
1100.–1200.			17	42.5
1200.–1300.				
1300.–1400.				
1400.–1500.				
1500.–1600.	19	47.5		
1600.–1700.	12	30.0		
1700.–1800.	7	17.5		
1800.–1900.	2	5.0		
Mean	$1,626.74		$1,069.91	
Median	1,605.37		1,147.79	
Mean Variation	76.15		52.60	

(After Viteles)

find it possible to do a business of approximately $6000.00 a year and to earn thereby net commissions of approximately $2000.00. With exactly the same working conditions, other drivers can do a gross yearly business of only $3000.00, with a net earning of approximately $1000.00.

The distribution of earnings [3] from March 1, 1925, to February 1, 1926, of 80 drivers, including approximately the best 25 per cent and poorest 25 per cent of drivers hired during 1924 in the service of a large eastern taxicab company, are shown in Table 2. Average earnings of the same group are shown in Figure 2. The average gross annual return per shift for each cab operated by the best drivers is close to $5000.00, whereas that of the poorest drivers is slightly more than $3000.00. In manufacturing plants such differences in gross returns are somewhat compensated for by a decrease in the amount of material, power, and other items employed by the worker whose earnings, on a

[3] From an unpublished study by the author.

production basis, are low. In the case of the drivers included in this study, the poorest ones were found to cover a somewhat greater proportion of "dead" miles, involving a greater consumption of gasoline

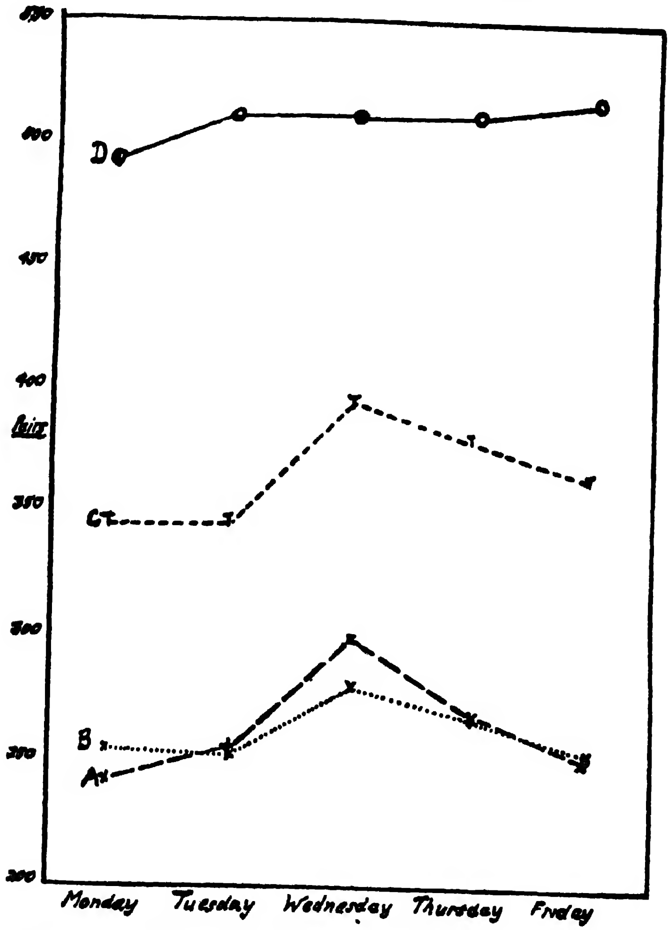


FIGURE 3. *Average Daily Output of Four Bottom Scourers (After Loveday and Munro)*

and more wear and tear on tires and equipment, than those with the higher earnings. They were also involved in more accidents. In addition, larger expenditures for compensation and health insurance, more frequent visits to the Medical Department contributed to increase further the per capita overhead cost to the operating company for drivers whose gross receipts and net earnings were low.

The magnitude of differences in productivity is also strikingly illustrated in the comparison of average daily production of four *bottom scourers* in the shoe industry in Figure 3, which shows the production of the better operative, suited to the job, to be consistently twice that of the unsuitable worker. A study of the weaving industry furnishes another illustration of the extent of individual differences in productive capacity and their significance. In this study [4] the "total number of yards of cloth produced from the warp was measured, and from this number, a knowledge of the cloth, of the time taken for weaving the cloth, the average rate of production in picks per minute was obtained. This number, expressed as a fraction of the speed of the loom, also measured in *picks* [5] per minute, gave the percentage efficiency for the warp." Table 3 shows the rate of production of warps on the same kind of cloth, "a plain cloth made from a raw silk warp with 112 double ends of silk per inch, shot with 72 threads per inch of a high grade highly twisted cotton weft of medium counts. . . . From this table will be clearly seen the huge variations in the rates of production of individual warps met with in practice. These variations range from a rate of 62 picks per minute, representing an efficiency of 43 per cent, to 130 picks per minute, representing 90 per cent efficiency. Another way of emphasizing this difference is to point out that while it took 318 hours to weave the former warp it took only 146 hours to weave the latter. The first weaver's hourly earnings were less than one half of the second weaver's, and from the employer's standpoint the second loom earned over twice as much profit as the first, and also more than twice the sum to meet the overhead charges in the same time."

The significance of such differences, from the viewpoint of selection, grows out of the possibility of choosing workers from the upper range

TABLE 3

Rates of Production on the Same Kind of Cloth

PICKS PER MINUTE	NO. OF WARPS	PICKS PER MINUTE	NO. OF WARPS
55–64	1	95–104	63
65–74	5	105–114	45
75–84	21	115–124	37
85–94	57	125–134	6

(After Elton)

of capacity and eliminating those in the lower ranges as a way of increasing individual efficiency and adjustment in the industrial plant. The importance of forecasting, at the time of employment, the final level

[4] P. M. Elton, "An Analysis of the Individual Differences in the Output of Silk Weavers," Ind. Fat. Res. Bd. *Report*, No. 17, (1922), pp. 8 ff.

[5] Every time the shuttle is thrown across the loom, a thread is left in the warp shed: the action of the loom in throwing the shuttle is spoken of as *picking*, and each thread left by the shuttle as a *pick*.

of proficiency has been brought out in an investigation, by Bingham,[6] of a group of women engaged in tending machines which wind paper insulations on strands of copper wire. Workers are guaranteed a minimum rate of 38¢ per hour from the beginning although services are not worth this minimum during the training period. The difference between actual earnings and guaranteed earnings during training constitutes a deficit which amounts to approximately $40.00 or $50.00 per employee. The interest and overhead on machines operated by girls amounts to about $2.25 an hour.

"Between a new operator who proves to be barely able to earn her way eventually and stay on the job, and one who finally attains to the upper quartile in proficiency, the difference in cost to the firm during a period of thirty-six weeks was found to be $390. This means that the employment interviewer, by selecting an applicant who will be among the best 25 per cent of those engaged on this job as compared with one who is barely able to succeed, saves the firm his own salary for a month."

The influence of individual differences is not confined to selection; it plays an important part in the prevention of accidents, in the development of training programs, in avoiding the problem of monotony, and in every other aspect of industrial life. An analysis of any problem of human behavior in industry leads to a consideration of individual differences and raises the questions of *how individuals differ, why they differ,* and the *significance of such differences in daily accomplishment.* The chief purpose of this chapter is to present an abstract of the most important findings relative to these questions as a background for the detailed description of the application of psychology in industry to be included in the chapters which follow.

RANGE OF DIFFERENCES

The first question to be raised in the consideration of how people differ is the magnitude of such differences, that is, the amount of difference between the most superior and the most inferior individual with respect to any trait. The significance of a difference varies with the total range of difference. A difference in 10 units per hour in production may have little significance if the range of production is from 150 units per hour on the part of the worst worker to 400 units per hour on the part of the best worker. The same difference of 10 units becomes extremely important from the viewpoint of efficiency if the total range of difference is from 60 for the worst to 85 for the best worker.

In so far as the magnitude of difference is concerned, the figures on earnings in Table 2 show the yearly earnings of the best driver to be approximately twice those of the worst. The ratio of performance between the best and the worst in the case of weaving is also approxi-

mately 2 to 1. The range and extreme measures of individual performance in available psychophysical and mental tests have been studied by Wechsler.[7] From the results of his investigation he concludes that "the limits of most human traits, when measured in comparable units and from true zero points, may be approximately expressed by the ratio of 2: 1"; that, in other words, the most superior individual on any mental trait or performance possesses capacity that is only twice that of the most inferior member of a "normal" group, that "the most efficient individual does not produce more than twice as much as the least efficient."

Further evidence on the magnitude of differences between the best and the worst individuals is furnished by Hull [8] from an unpublished study by Limp. The latter gave 34 standard psychological tests of the group type to 107 first year high school students. The presence of zero

TABLE 4

Showing the Relation of the Poorest Performance to the Best Performance of 107 Ninth Year Pupils. (Data furnished by Charles E. Limp)

NATURE OF TEST	AUTHOR OF TEST	LOWEST SCORE	HIGHEST SCORE	RATIO OF LOWEST TO HIGHEST
Information	Terman (group)	1	19	1:19
Analogies	" "	3	17	1:5.7
Classification	" "	7	17	1:2.4
Motor reaction	Hoke (shorthand)	27	90	1:3.3
Speed of writing	" "	14	73	1:5.2
Quality of writing	" "	30	90	1:3
Speed of reading	" "	20	68	1:3.4
Immediate memory	" "	15	88	1:5.8
Spelling	" "	8	60	1:7.6
Symbols-speed	" "	14	75	1:5.6
Speed of decision	Downey (group)	2	10	1:5
Freedom from load	" "	2	20	1:10
Motor inhibition	" "	1	10	1:10
Volitional perseveration	" "	3	16	1:5.3
Interest in detail	" "	2	10	1:5
Self-confidence	" "	1	10	1:10
Easy directions	Woodworth & Wells	4	20	1:5
Cancellation (A-test)		37	82	1:2.2
Vocabulary		4	34	1:8.5
Dotting squares	Henmon	40	138	1:3.4

(After Hull)

[7] D. Wechsler, "The Range of Human Capacities," *The Scientific Monthly,* 31 (1930), pp. 35–39.

[8] C. L. Hull, *op. cit.,* p. 33.

scores makes it impossible to secure meaningful ratios for 13 of these tests. In the remainder (Table 4) it is found that at one extreme the best person obtains a score 2.2 times that of the worst, while at the opposite extreme the best person scored 19 times as high as the poorest. The middle ratio of Limp's results shows the best person making a score 5.2 times as large as the poorest.

Hull has also assembled from various sources distributions showing the extremes of efficiency of persons actually engaged in gainful occupations (Table 5). At one extreme, in the case of heel trimming, the best worker is shown to produce only 1.4 times as much as the poorest, whereas in the case of polishing spoons the ratio of the best to the poorest is 5.1 to 1. The middle ratio is 2 to 1.

In the case of practically every illustration included in this discussion of the extent of differences in human capacity there has been some selection of cases. Individuals rating lowest in the traits measured by tests in Limp's study, for example, would not be found in the first year of the high school. In the same way, the fact that extremely poor work-

TABLE 5

Showing the Ratio of the Least Efficient to the Most Efficient Actually Engaged in a Variety of Gainful Occupations

SOURCE	VOCATION	CRITERION	RATIO OF POOREST TO BEST WORKER
Loveday and Munro	Heel trimming (shoes)	No. pairs per day	1:1.4
Elton	Loom operation (silk)	Per cent of time loom kept in operation	1:1.5
Pollock	Hosiery maters	Hourly piecework earnings	1:1.9
Wyatt	Loom operation (fancy cotton)	Earnings	1:2
Loveday and Munro	Bottom scouring (shoes)	No. pairs per day	1:2
Pollock	Knitting-machine operators	Pounds of women's hose per hour	1:2.2
Scott and Clothier	Office boys	Weekly salary	1:2.3
Hertzberg and Thiel	Elementary teachers	Ratings of superiors	1:2.5
Farmer	Polishing spoons	Time per 36 spoons	1:5.1

(After Hull)

ers are not continued in employment tends to prevent the incidence of extremely low scores among those engaged at work. This factor tends to decrease the range between the poorest and best—to reduce the ratio of efficiency between the extremes of performance. On the other hand, as Hull points out, "a person may make a low or even a zero score on some of the tests on the list, yet possess an appreciable amount of

the ability being measured. This tends to make the ratios on this table unduly large." Taking these factors into consideration, it seems justifiable, from the evidence that is available, to agree with Hull that "we shall probably not be in great error if we conclude that *among individuals ordinarily regarded as normal, in the average vocation, the most gifted will be between 3 and 4 times as capable as the poorest.*"

The smallness of the ratio between the two extremes of the range of ability has led a few investigators to the conclusions that differences have been over-emphasized in the discussion of human make-up, and that the variability of human individuals is perhaps less significant than the prevailing homogeneity of the human type. This point of view is well represented in an article by Wechsler,[9] in which the doctrine of human equality with all its wide-spread political, social, and economic implications is defended on the ground of the relatively short range of scores, and of the small ratios of extreme scores in representative samplings of human traits. Viewed as a numerical relationship, the ratio of most superior and inferior performance, particularly in the light of the wide range of finite numbers and of their ratios, appears infinitesimal. But when it is considered that a 10 point difference in the ratio of 8 to 7 between an *Intelligence Quotient* of 80 and an *IntelligenceQuotient* of 70 may be equivalent to a difference between confinement in an institution and self-supporting and self-respecting citizenship; when it is recalled that a difference in earnings of 2 dollars a week in a total range of from 18 to 36 may decide between continued employment and discharge, arguments of this kind take on the habiliment of a somewhat interesting but profitless sophistry.

THE DISTRIBUTION OF INDIVIDUAL DIFFERENCES

The range and extent of individual differences give no clue with respect to the pattern of their distribution among a group of individuals. For example, the distribution from one end of a scale of performance to another may be along a straight line, such as in the *assumed* distribution of the number of locks packed per hour shown in Figure 4A. Of 140 workers engaged in packing locks, 20 average between 200 and 220 locks per hour; 20 between 220 and 240. Twenty workers are found in each interval of 20 points. Such a distribution would result if there were the same number of workers at each of the levels of proficiency between that of the poorest and that of the best worker in a group. Actually, of course, there is no such regular distribution of ability at each level.

There are other ways in which differences may be distributed. So, for example, from the viewpoint of proficiency in assembling locks, workers may be concentrated at the two ends of the scale, as shown in the *assumed* distribution of the rate of packing locks in Figure 4B. In

[9] D. Wechsler, *op. cit.*

this distribution there appears a large group of "fast" workers at one end of the scale, a large group of "slow" workers at the other end of the scale, and a small scattered group which may be designated as "fair" or "middling" workers. Actually the distribution shows two dis-

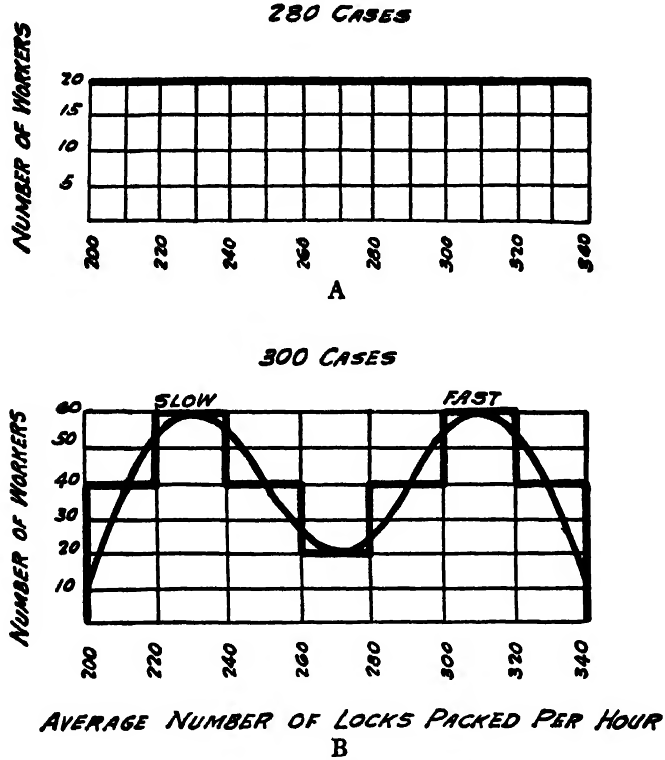


FIGURE 4. *Assumed Distributions of Average Number of Locks Packed Per Hour*

tinct "types," the "fast" and the "slow," the middle group representing a straggling of workers at the edges of each of the other two groups.

The common tendency is to assume that differences do distribute themselves in exactly this way. The human mind seems to favor dichotomy in descriptive classification. Perhaps the two most commonly used descriptive terms are "all right" and "no good," with such intermediate classifications as "passable," "fair," "pretty good," lagging far behind with respect to frequency of usage. Many other instances of the assumption that the body of mankind is made up, in the main, of two distinct, widely separated classes can be cited, ranging from the "just," and the "unjust," the "chosen people" and "other nations" of the Bibli-

cal age to the "introvert" and "extrovert" of modern times. Occasionally the number of classes may be increased as, for instance, to the 4 types associated with the 4 bodily humours of the Grecian philosophers, but the gaps between the classes remain wide, and even here dichotomies such as phlegmatic versus choleric, melancholic versus sanguine are introduced.

Among the most important of the contributions from the study of individual differences is the accumulation of data to show that, in spite of the common belief, differences do not distribute themselves in such a way as to create two or more widely separated groups or "types." "The variations in any single trait are usually continuous, and they represent variations, in degree, around one and only one type." [10]

The characteristics of this usual type of distribution can be illustrated by a consideration of the statures of American boys ten and a half years old. This distribution is roughly as follows:— [11]

Between	109	and	113	cms.	tall	2	boys
	113	"	117	"	"	5	"
	117	"	121	"	"	25	"
	121	"	125	"	"	97	"
	125	"	129	"	"	199	"
	129	"	133	"	"	255	"
	133	"	137	"	"	228	"
	137	"	141	"	"	126	"
	141	"	145	"	"	49	"
	145	"	149	"	"	11	"
	149	"	153	"	"	4	"

Graphically presented the distribution is as in Figure 5. It shows, first of all, no gap between the shortest and the tallest in stature, but a continuous progression in height between the two extremes, individuals being found of every height from 110 to 153 cms. There are very few extremely short or extremely tall boys in the group. A boy over 149 cms. in height is distinctive in the sense that this height occurs only once in 250 times, but not in the sense of being removed from ordinary children by a distinct gap. The typical or "modal" height for this group is about 133 cms., in the sense that a large proportion of the children tends to cluster around this height. Moreover, there is only one such clustering or "mode," indicating the existence of only a single type in so far as height of children of this age is concerned. A large proportion of the group is close to the "average" in height, an average obtained by dividing the combined heights of all the children by the number of children. Moreover, the "average" height—the arithmetic "mean"—is extremely close to the height of the child in the exact middle of the group from the viewpoint of stature, technically known as the

[10] E. L. Thorndike, *Individuality*, Cambridge, 1911, p. 13.
[11] *Ibid.*, pp. 8–9.

"median" height, and to the "mode" or height at which is found a greater number of children than at any other single height. Other interesting characteristics also appear in this distribution. Slight individual variations from the type—as established by the "average," the "median," the "mode"—are numerous, but large variations from it are rare. Moreover, there is a definite inverse relationship between the number of children at a given height and the amount of deviation of that height from type. At 121 cms. there are fewer children than at 129 cms.; at 145 cms. there are fewer children than at 137 cms.

Evidence from a large number of studies shows that physical and

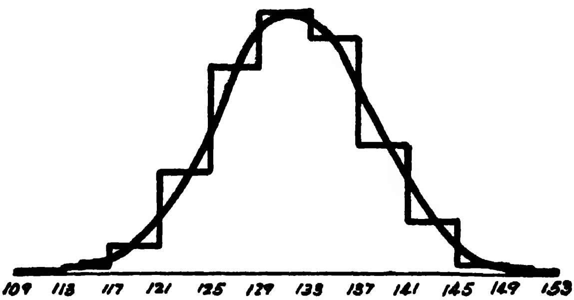


FIGURE 5. *The Distribution of Stature of American Boys 10 1-2 Years Old (After Thorndike)*

mental traits are distributed in this manner. It seems to be the "chance" distribution of natural phenomena as varied as temperature and general intelligence, as is clearly indicated in the graphs presented in Figure 6. This type of distribution occurs so frequently in the measurement of human traits that the curve representing it has come to be known as the *normal frequency* or *distribution curve,* or simply as the *normal curve.*[12] Figure 7 shows the ideal form of such a distribution, in other words a *normal frequency curve.* The frequency of appearance of the "normal" curve is good reason for strongly suspecting that measurements of human capacity which distribute themselves other than in this way are subject to the undue influence of some single factor or combination of special factors perhaps not recognized by the experimenter in the selection of his cases. So, for example, a small number of cases may give gaps in the distribution, and exhibit an apparent existence of types. The Intelligence Quotients of college students will tend to pile up at the upper end of the distribution because, in general, only the most intelligent of

[12] For a fuller description of the characteristics of the curve and a discussion of its mathematical derivation see any standard text on statistics. A volume by H. E. Garrett, *Statistics in Psychology and Education,* New York, 1926, pp. 312, is probably best adapted for the needs of undergraduates and other readers interested in a more detailed description of statistical concepts employed in this text.

the population are admitted to college. Such a concentration of cases, either at the lower or upper end of the curve, can be expected when cases have undergone such selection. The test scores on a typing proficiency examination of employed typists and stenographers can be ex-

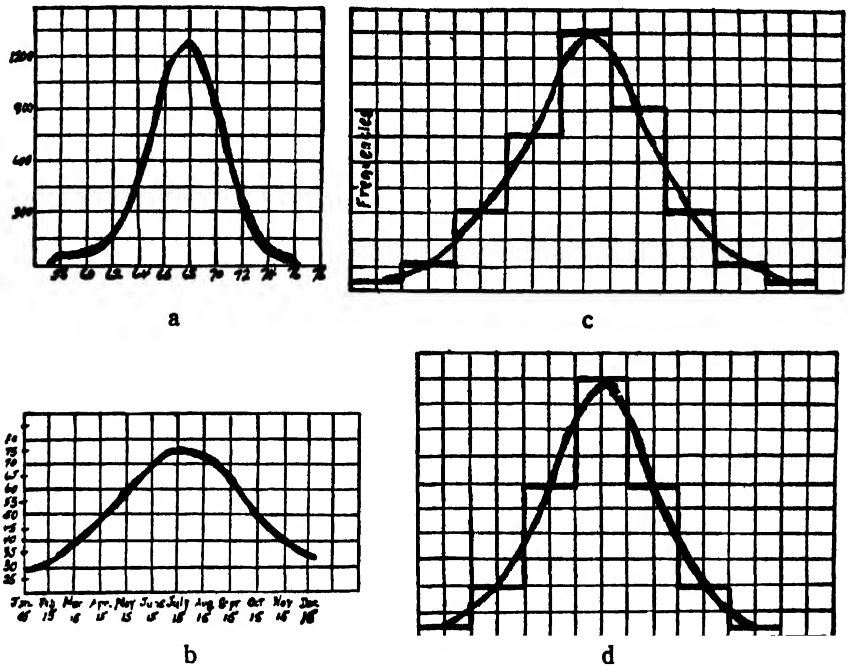


FIGURE 6. *Samples of Frequency Distributions Drawn from Different Fields*

a. *Stature of 8585 adult males born in British Isles*
(*After Yule, page 89*)

b. *Mean monthly temperatures, N. Y. C., Jan.-Dec., Average for 47 years*
(*After Kelley, page 28*)

c. *IQ's of 905 unselected children 5–14 years old*
(*After Terman, page 66*)

d. *Memory span for digits, 123 adult women students*
(*After Thorndike, page 99*)

(*After Garrett*)

pected to be skewed as in Figure 8A, because the least proficient typists are quickly dropped from the roll by reason of their failure to meet the proficiency standards of the employing company.

In certain instances, *a bi-modal distribution,* such as shown in Figure 8B, may be obtained because of the highly selective conditions under which measurements are made. In an examination of proficiency in dictation and transcription by stenographers such a distribution gives an

concepts most frequently employed in the statistical description of variability are

1. *Mean Variation* (M.V. or M.D. or A.D.)
2. *Standard Deviation* (S.D. or σ)
3. *Probable Error* (P.E.)
4. *Semi-Interquartile Range* (Q)
5. *Coefficient of Variation* (V)
6. *Skewness*

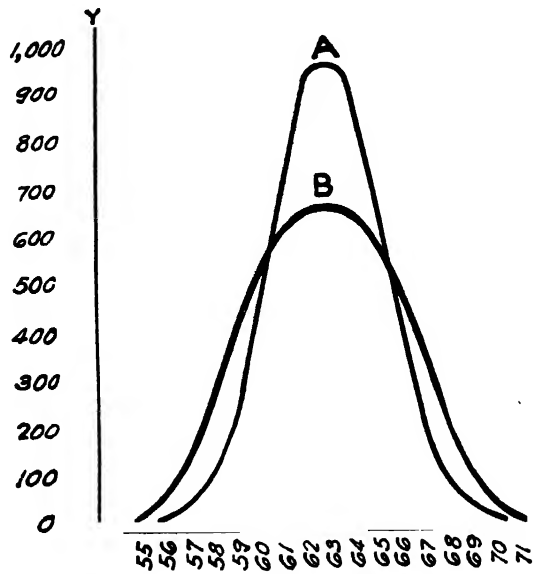


FIGURE 9. *Comparison of Absolute Amounts of Variability in Different Distributions*

(*After Chaddock*)

Of these, the first four are measures of *absolute variability* and indicate, in a general way, the relative homogeneity or heterogeneity of the measures. They show broadly the character of the dispersion of the data from some measure of central tendency of the group—most gen-

will be no attempt to describe methods for computing statistical measures, to discuss in detail the derivation of statistical procedures and theories, and the rules which should govern their application. However, reference must be made to such measures and procedures in order to clarify certain portions of this text, and to aid in the evaluation of experimental results in the field of industrial psychology. For this reason, a brief description of certain terms will be included. It is assumed that the student of applied psychology will have already familiarized himself with the statistical methods and theories most commonly employed in applied psychology.

erally the *average* or the *median*. In the case of the relatively homogeneous group, which is characterized by a marked concentration of cases around the average (as in Curve A, Figure 9) both the M.V. and S.D. will be relatively low. On the other hand, if there is a tendency for a large number of the measures to be scattered away from the average, as in the case of a relatively heterogeneous group (Curve B, Figure 9), the M.V. and S.D. will be high.

1. *Mean Variation*

The procedure for calculating the M.V. is such that in a normal distribution 57.5 per cent of the measures will be found between a point lying 1 M.V. below the average and a point lying 1 M.V. above the average. So for example, with an average of 50 and an M.V. of 5, 57.5 per cent of the cases will be found between 45 and 55.

2. *Standard Deviation*

The S.D. is so calculated that in a normal distribution approximately 68.26 per cent of the cases will lie between the average *plus* and *minus* the S.D. Moreover, in a normal distribution over 99 per cent of all the measures will lie between the average *plus* and *minus* 3 S.D. These points, derived from the point of change in steepness or *inflection* of the curve have been marked off in the normal curve shown in Figure 7. The S.D., commonly designated by the Greek letter sigma, σ, is the most frequently employed measure of variability and is of great significance in connection with the use of psychological tests and in the analysis of other psychological data in the industrial situation.

3. *Probable Error*

The probable error (P.E.) has somewhat the same general significance as the standard deviation. As a matter of fact, it is usually computed by simply calculating .6745 of the standard deviation. Between a point lying 1 P.E. below the average and a point lying 1 P.E. above the average are to be found 50 per cent of the measures in a normal distribution curve. The average *plus* and *minus* 4 P.E. embraces over 99 per cent of all the measures in such a curve. The P.E. points are also indicated on the normal probability curve in Figure 7.

4. *Semi-Interquartile Range*

The semi-interquartile range or Q is a measure of dispersion or variability obtained by considering the range of the middle 50 per cent of the measures where they have previously been arranged in order from highest to lowest. Actually, it is obtained by halving this distance. In this way is obtained a measure of variability of the middle half of the measures uninfluenced by extreme measures which may be found at the upper or lower end of the distribution.

5. *Coefficient of Variation*

The coefficient of variation or V is used as an index of relative variability. We may, for example, have two sets of test scores, one with an average of 50 and the other with an average of 30. An S.D. of 5 is not equally significant in both cases inasmuch as the S.D. represents a smaller proportion of the average in the first set of measurements than in the second. A comparison of the degree of variability of these two groups involves the computation of V, or coefficient of variation, which is a measure of relative variability obtained by dividing the standard deviation $\times$ 100 by the average. The calculation of the coefficient of variation in the cases cited above will show that V has a value of 16.8 in the case of the second group, and a value of 10 for the first group. In other words, in spite of the identity of the S.D. the second group is actually more variable than the first. V may be used not only in computing relative variability of distributions in which the measures are the same, but the relative variability of entirely distinct measures such as pounds of weight, inches of height, units of intelligence test scores, etc.

6. *Skewness*

In an earlier paragraph it has been pointed out that not all distributions are normal—that, under certain conditions, there may be a more marked dispersion of measures in one direction or in another. A distorted dispersion of this kind (illustrated in Figure 8A) is described as *skewed* and is graphically presented in a curve that shows skewness. Both the direction and amount of skewness can be statistically computed and presented in a *coefficient* of *skewness*. In the case of such a coefficient, a plus sign preceding the coefficient indicates a concentration of cases at the low end of the range of measures or ***positive skewness***. Where the coefficient is preceded by a minus sign, a concentration of cases at the high end of the range of scores, or ***negative skewness***, is indicated.

TRAIT DIFFERENCES

The study of the range and distribution of mental traits in groups has revealed the existence of many traits. It has also pointed to the presence of general laws governing the distribution of a single trait in a group of individuals, and has suggested the existence of a "psycho-biological constant" [14] in the form of a definite relationship on any trait between the poorest and best individual in a "normal" group.

In addition to the distribution of traits in different individuals, it is important to consider the distribution of varied traits in the same individual. The nature of the distribution of traits, of ***trait differences***, in the individual has many practical implications for vocational adjust-

[14] D. Wechsler, *op. cit.*

ment. If, for example, superiority in one trait is invariably associated with superiority in other traits and, inversely, inferiority in one trait with inferiority in others, the problem of personnel selection and of individual adjustment in the industrial organization becomes tremendously simplified. Under such circumstances, superiority in one trait or in one field of activity may be accepted as indicating superiority in other fields of work. A good punch press operator can, for example, be transferred to the assembly department with a fair assurance that, after suitable training, he will become a highly satisfactory employee in this other type of work. Industrial mobility remains free and untrammelled by variations in capacities requiring careful and painstaking study before a transfer can be made. If, on the other hand, there is little or no relationship among different traits in the same individual, the problems of selection, transfer, promotion—of adjustment and efficiency in general—increase in complexity in direct proportion to the extent of variety of relationships among human traits in the single individual.

Popular opinion favors the belief that there is no direct or "positive" relation among traits. On the campus, for example, the fact that those elected to honorary scholastic societies such as Phi Beta Kappa are not always the leaders in social and extra-curricular activities has suggested that superior scholastic aptitude is not necessarily associated with superior social talents and capacity for leadership. In the industrial plant the layman, more particularly the industrial executive, has found that the most skilled machinist is frequently unsuited for the position of foreman. Many an excellent accountant, highly proficient and diligent in the performance of his task, has been ruined by promotion to a supervisory position. Superiority in the capacity to perform a task, it is pointed out, does not denote superiority in guiding the performance of other workers on that job. Such observations, carried to their apparently logical conclusions, have even led to the popular acceptance of a principle of compensation expressed, for example, in the beliefs that rapid learners forget quickly; that the college professor, engrossed in theoretical abstractions, has a poor memory; that artistic talent is invariably associated with an inability to deal well with practical everyday affairs, and so on. The extreme of this position is very well illustrated in the not uncommon patronizing attitude toward the genius, "who is to be pitied rather than envied for his one-sided superiority. . . . Though able to attain higher degrees of happiness than a normal man he has to experience proportionately higher degrees of unhappiness, and often has to pay a great price for the use of his talent." [15]—The mental depression of Cowper, poet and humorist, the hypertrophied hearing of Carlyle, deMusset, Goncourt; the vertigo of Napoleon; the nervous disorders of Handel, Beethoven, Wagner; the epilepsies of the great, are cited in illustration of the peculiarities and deficiencies, physi-

[15] B. DeBakhtiar, "Should Great Men Be Envied?" *U.G.I. Circle*, 12 (1931), pp. 14–17.

cal and mental, which compensate for the superior and often specialized talent of the genius.

The position of the psychologist on this complicated problem of trait differences in the individual is a somewhat uncertain one. The findings in this field are neither as numerous nor as conclusive as in the measurement of individual differences in the same trait existing among the members of a group. Moreover, there has been practically no large scale investigation of trait differences of workers directly related to their performance on industrial tasks. However, there are a few selected studies and observations which have a bearing on this problem and which may at least contribute toward the formulation of a viewpoint with respect to the nature, relationship, and significance of trait differences in the adjustment of the individual to the industrial situation.

The traditional viewpoint with respect to this problem is that of Thorndike [16] who concludes that "all trustworthy studies so far made of the relations between the amounts of desirable single traits in the same individual agree in finding direct or positive relations between such traits. Having a large measure of one good quality increases the probability that one will have more than the average of any other good quality. He who can learn better than the average through the eyes, tends to learn better than the average through the ears; also he who can attend to one thing better than all other men, will be able to attend to many things at once or in rapid succession better than most of them. Artistic ability, as in music, painting, or literary creation goes with scientific ability and matter-of-fact wisdom. The best abstract thinker will be above the average in concrete thought also. The rapid workers are the more accurate. Intellectual ability and moral worth hang together."

This position is substantiated by Terman's well-known study of superior children, [17] which shows conclusively that superior children tend to be above average on all desirable traits. They are physically somewhat above the average. They show better control than the average. They are more likely than the average to possess good musical and artistic ability.

A number of studies have indicated a tendency for an individual who does well on one type of test ordinarily employed in "general intelligence" scales to do well in others of the same type. This is strikingly revealed, for example, in an analysis of scores made by 1000 Army recruits on each of the 8 tests included in the Army Alpha, which shows that in the majority, although not in all, an increase in the amount of one trait as measured by the test is accompanied by an increase in the amount of the others with which comparison is being

[16] E. L. Thorndike, *op. cit.*, p. 26.

[17] L. M. Terman, et al., *Genetic Studies of Genius*, Vol. I, Palo Alto, 1925, pp. 648.

made.[18] On the other hand, there is definite evidence in the work of Stenquist,[19] Toops [20] and others that the capacity to handle abstract ideas as measured by the standard general intelligence scale is not generally in direct relation to the capacity to do well in performances involving "mechanical ability." Moreover, success in one kind of motor performance appears to bear no relation to success in others. Perrin,[21] for example, applied 17 "motor tests", including tests of aiming, tapping, steadiness, etc., to 51 students. An examination of his results shows little agreement between the performance of an individual on one of these tests and on any of the others in the series.[22] A comparative survey of performance on similar motor tests led Muscio to conclude that "motor capacities appear to vary independently of one another . . . an individual's performance in one such activity is not, in general, the slightest indication of what his performance in another such activity will be." [23] Comparison of tests of "manual dexterity" applied to 1000 children by Earle and Gaw [24] shows a high degree of independence of abilities measured by them, the degree of success in each appearing to be largely specific to the test situation.[25]

From an analysis of the school performance of children, similar findings are available. In schools are found children with generally good academic averages who are poor in arithmetic; good arithmeticians who do not learn to spell well; and individuals who are deficient in arithmetic, reading, spelling, and all other academic subjects, who do remarkably well in carpentry and clay modelling. This is illustrated in Figure 10 a [26] showing the profile of a girl 10 years and 2 months of age somewhat better than average in general school performance, but with a special defect in arithmetic. The analysis of individual test performance in the industrial situation reveals similar discrepancies in performance and tests measuring industrial traits. This is clearly shown in Figure 10 b, the test profile of an applicant for the position of electrical substation operator, in whose case superior performance on a test of the ability to follow directions is combined with inferior performance in tests of motor learning (Learning Test), of analysis (Puzzle Box and Series Discrimination), etc. Figure 10 c, the test

[18] Coefficients of correlation range from $+0.59$ to $+0.86$, *Memoirs, National Academy of Sciences*, 1921, Vol. 15, pp. 890.

[19] J. L. Stenquist, *Measurements of Mechanical Ability*, Teachers College, Columbia University, 1923, pp. 101.

[20] H. A. Toops, *Tests for Vocational Guidance of Children*, Teachers College, Columbia University, 1923, pp. 153.

[21] F. A. C. Perrin, "An Experimental Study of Motor Ability," *Journal of Experimental Psychology*, 4 (1921), 24–56.

[22] Coefficients of correlation ranging from -0.22 to $+0.39$.

[23] B. Muscio, "Motor Capacity," *British Journal of Psychology*, 13 (1922), pp. 57–84.

[24] F. M. Earle and F. Gaw, "The Measurement of Manual Dexteriy," *Report of the National Institute of Industrial Psychology*, London, 4 (1930), pp. 88.

[25] For a fuller description of these studies and their implications see Chapter XII, pages 231–38.

[26] C. Burt, *The Distribution and Relation of Educational Abilities*, London, 1917, p. 64.

profile of an employed male examined in connection with the Minnesota Unemployment Research Project, shows an absence of any tendency toward comcomitant variation in mental traits upon which earlier investigators have insisted.[27]

Among the most important of recent investigations of this problem is a study by Hull.[28] "The subjects were 107 first year high school students. They were tested by means of 35 standard psychological tests involving a considerable variety of functions. In order to facilitate

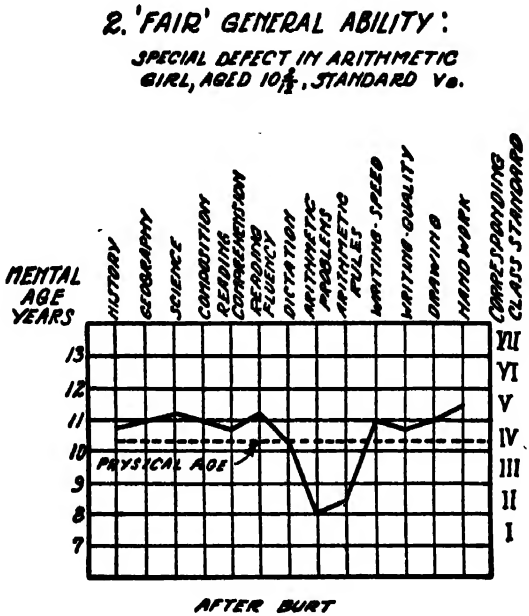


FIGURE 10a. *Psychograph of Special Educational Ability*
2. *'Fair' General Ability*

(After Burt)

comparisons, the scores on the 35 tests were all compiled into equivalent values . . . The trait distributions of various subjects were plotted from these data. The general contours of these graphs were somewhat irregular, owing to the small number of items (35) involved in each. Invariably there appeared a distinct tendency to approach the characteristic shape of the normal probability curve. In order to secure a clearer picture of the distribution of trait magnitudes, the scores of certain subjects having approximately the same mean of talent and

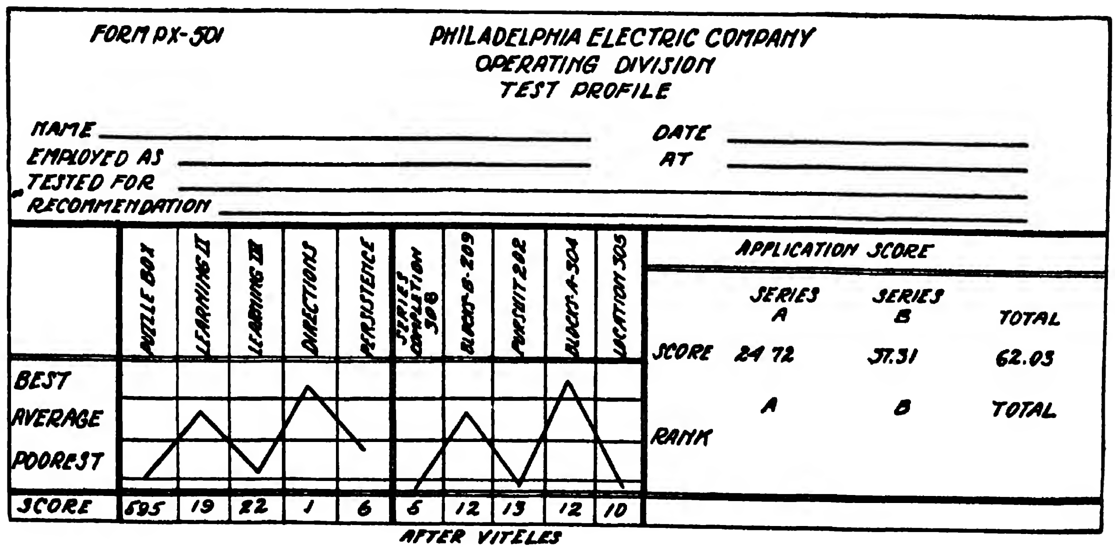


Figure 10b. *Philadelphia Electric Company, Operating Division, Test Profile*

(*After Viteles*)

degree of talent variability were pooled. The resulting distribution is shown in Figure 11. The proximity to the shape of the normal curve is unmistakable. The same tendency was noted in several other distributions of a like nature. *The indication is clear that the distribution of*

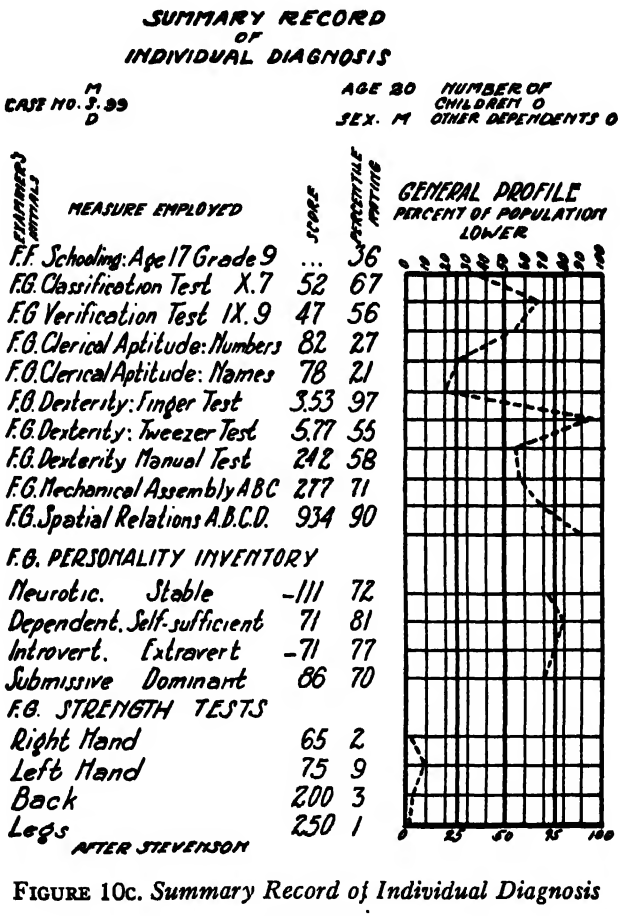


FIGURE 10c. *Summary Record of Individual Diagnosis*

(*After Stevenson*)

talent within an individual follows the normal law much as do the distributions of individual differences."[29]

A further analysis of the data showed that from the viewpoint of the variability of traits within the individual some individuals are twice as variable as others. Moreover, "after a certain allowance had been made for errors of measurement, it was concluded that the

[29] Italics by the author.

trait differences here investigated average approximately 80 per cent as great as individual differences."

The general import of these findings is clear. The individual is not superior in all traits, average in all traits, or inferior in all traits, but represents a combination of superior, average, and inferior traits. Since

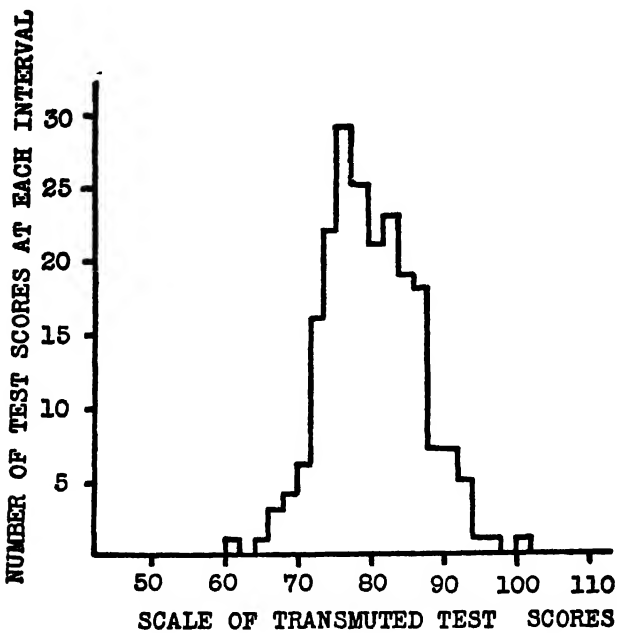


FIGURE 11. *Composite Trait Distribution of Six Subjects Having Approximately the Same Trait Means and the Same Trait Standard Deviations, All Being in the Middle Range*

(*After Hull*)

the distribution of traits in the individual is in accordance with the normal law, the great majority of his capacities or traits will be close to the average of his traits, but in a few traits there will be marked weaknesses, and in a few others, marked strength.

"If," Hull writes,[80] "subsequent investigations shall show that the results obtained in this study hold true of genuine vocational aptitudes, it will mean that the average person has a great variety of occupational potentialities . . . We have already seen reason to conclude that the best person in a normal group is between three and four times as efficient as the poorest. If the variability within the individual is 80 per cent as great as that, then the average individual's best vocational potentiality

[80] C. L. Hull, *op. cit.*, p. 49.

must be between two and one half and three times as good as his worst."

The implications of these conclusions for vocational adjustment are far reaching. They suggest that individuals who are successful on one job will not necessarily excel in others to which they may be transferred in the same plant. What is perhaps of still greater importance, the conclusions suggest that for the man who is inefficient and maladjusted in one occupation, there are other jobs involving traits in which he is superior that will coincide as nearly as possible to his maximum vocational potentialities. The recognition that traits do vary in the same individual, that there is a diversity of potentialities among them, instead of a dead level of uniformity, gives reason for expecting valuable results in improved adjustment from a scientific matching of capacity and occupation through scientific selection, supplemented by a process of dynamic transfer and adjustment throughout the individual's period of work in an industrial organization.

VII. THE ORIGIN OF INDIVIDUAL DIFFERENCES

The proof that differences exist, that they distribute themselves according to established laws both in the group and within a single individual, gives no clue to the origin of these differences. Simply stated, there still remains the problem of determining how these differences arise, whether an individual is "industrious" because he has been born with a capacity or inclination for prolonged effort, or whether by reason of training or experience he has developed a habit of exerting maximum effort at the task on which he is engaged. Does the school boy fail in his carpentry class, in spite of his efforts, because he has not inherited the necessary "mechanical" aptitude or because a home environment free from the opportunity or incentive to do "odd jobs" has failed to stimulate the development of this aptitude? With respect to a group of workers there is always the question of whether differences in production are the result primarily of differences in "aptness" for the work, variations in length of service, individual incentives, or diversity in methods employed in teaching the operations of the job.

Perhaps on no aspect of human behavior is there greater diversity of opinion than on this question of the origin of individual differences. Among laymen there are ardent advocates of a doctrine of "determinism" which makes all variations inborn, the direct result of inheritance; and equally ardent advocates of the opinion that training, surroundings —the environmental conditions of life—literally "make the man." Among biologists, sociologists, psychologists there is similar diversity of opinion—similar divisions into camps which wage at least verbal warfare over their disputed positions. As a matter of fact all too frequently [1] the controversy has descended from the level of scientific evidence to that of acrimonious asservation and emotional appeal.

"The potency of environment," writes Pintner,[2] "is not nearly so great as commonly supposed. . . . A child's abilities are determined by his ancestors, and all that environment can do is to give the opportunity for the development of his potentialities. It cannot create new powers or additional abilities."

"Our conclusion," writes Watson,[3] "is that we have no real evidence

the persistence of mental defect in a family train is the first example of this approach. Dugdale found that of 1200 descendants of a shiftless truant, born in 1720, only 20 had learned a trade. Estabrook's follow-up 40 years later showed no improvement in the family stock. Goddard's [9] study of the Kallikak family furnishes another illustration of the investigation of a family tree through successive generations to determine the frequency of a given trait. In this instance, the investigator traced the ancestry of a girl in an institution for the feeble-minded. She proved to be one of a long line of feeble-minded descendants from the illegitimate mating of a Revolutionary soldier—a normal adult—with a feeble-minded woman. Among 480 direct descendants there were to be found only 46 normal individuals. A later marriage of the same man with a normal woman resulted in a long line of intelligent and, in some instances, superior individuals with an incidence of only 5 feeble-minded

TABLE 6

Number of Eminent Relatives of 977 Eminent Men

	JUDGES	STATESMEN	COMMANDERS	LITERARY MEN	SCIENTIFIC MEN	POETS	ARTISTS	DIVINES	TOTAL
Number	262	130	89	119	148	57	97	75	977
Father	22	13	12	16	11	4	9	7	94
Brother	30	15	13	14	20	8	14	9	123
Son	31	19	8	17	26	9	25	10	45
Grand-father	13	11	4	8	6	1	2	5	50
Uncle	15	7	2	8	7	1	4	10	54
Nephew	16	7	9	8	10	10	5	1	66
Grandson	16	4	3	3	6	1	5	4	42
Number of Eminent Relatives	143	76	51	74	86	34	64	46	574

(After Galton)

persons among 496 included in the survey. The presence of feeble-mindedness in successive generations of related individuals "leaves no doubt," according to Goddard, "of the hereditary character of this mental defect." Further evidence of the same type is presented by Winship [10] in a survey of 1400 descendants of Jonathan Edwards' family and by

[9] H. H. Goddard, *The Kallikak Family*, New York, 1913, pp. 121.
[10] A. E. Winship, *Jukes-Edwards, A Study in Education and Heredity*, Harrisburg, 1900, pp. 88.

Estabrook and McDougle [11] in a more recent survey of the "Win" tribe, an Indian-Negro-White mixture.[12]

b. *Statistical Studies of Family Resemblance*

Family studies on the influence of inheritance have been supplemented by a careful statistical comparison of the degree of resemblance between related, as compared with unrelated, individuals on various physical and mental traits. The underlying assumption of this type of study is that inheritance, if influential, will "cause children to deviate from the general average toward the condition of their parents, and to vary less among themselves than would the same number of unrelated individuals." [13] The difference in degree of resemblance among related and unrelated individuals can, therefore, it is further assumed, be accepted as a measure of the direct influence of heredity in producing individual variations.

In this type of study the resemblance between individuals is generally designated by means of a *coefficient of correlation*.[14] The coefficient of correlation represents a numerical statement of the amount of resemblance among individuals on any trait.[15] "If the coefficient is low

[11] A. H. Estabrook and I. E. McDougle, *Mongrel Virginians*, Baltimore, 1926, pp. 205.

[12] It is interesting to note that, largely as a result of such studies, earlier investigators tended to regard feeble-mindedness as a unit trait, a distinct entity obeying the same laws in inheritance as color of eyes, pigmentation, etc. Conceiving feeble-mindedness as a "recessive" trait, obeying Mendelian laws in transmission, they contended that no two feeble-minded individuals could ever possibly produce a normal offspring. This concept has been considerably modified in the light of more recent biological findings and theory. A more recent conception of the process of heredity, termed the theory of cumulative Mendelian genes, represents a modification of the old supposition. (See B. S. Burks and T. L. Kelley, "Statistical Hazards in Nature and Nurture Investigations," *27th Year Book*, Nat'l Soc. for the Study of Ed., Bloomington, Ill., Part I, 1928, pp. 9–35.) This proposal includes the proposition that intelligence is determined by three cumulative pairs of genes in which there is no dominance and no epistacy. "The thing to be emphasized here," it is asserted, "is that the right combination of two feeble-minded parents can occasionally produce normal offspring if cumulative genes account for intelligence, whereas this would not be possible by a simple Mendelian theory." Whether or not we accept this particular formulation of the theory of cumulative genes, it is evident that some such conception must supplant the old idea of unit character, for though undoubtedly some characteristics in some species are inherited in this fashion, it is equally evident that intelligence in the *homo sapiens* is not. H. S. Jennings has also shown (See H. S. Jennings, *The Biological Basis of Human Nature*, New York, 1930, pp. 383) how two defective parents can yield normal offspring among flies. He presents diagrams which illustrate the possible gene formations which could result in parents with hereditary defects producing offspring with none, and parents having no personal defects producing offspring with many.

[13] E. L. Thorndike, *Educational Psychology (Briefer Course)*, Teachers College, Columbia University, 1914, p. 441.

[14] *Ibid.*, p. 357.

[15] The coefficient of correlation is a statistical index for expressing the relationship or degree of resemblance between variables. One method used in arriving at this coefficient is illustrated in Figure 12, showing the position of 18 employees at the time of their first examination on a series of tests used in the selection of substation operators and the position of the same employees at the time of re-examination some 10 months later. An examination of this chart makes it evident that the ranks of these individuals remain relatively constant. In other words, there is close agreement or resemblance between results of the first and second examination. As a matter of fact, the agreement in this case is such as is expressed in a coefficient of correlation of 0.79. If there were no such agreement there

and approaches zero, there is no resemblance in the trait in question among the individuals compared. Chance pairs of unrelated individuals show zero correlation for psychological traits, because there is no factor at work making for a resemblance among such chance selections of individuals. If, now, there is a greater resemblance among related than among unrelated individuals, this will show itself in a higher coefficient of correlation among the related individuals. And we do find such higher correlations among related individuals. This does not constitute *proof* that heredity is the factor causing the resemblance, but, since the two groups are the same in every respect in the matter of relationship or non-relationship, it would *seem* that the factor of heredity is the cause of the resemblance." [16]

In color of eyes, color of hair, height, cephalic index (ratio of width to length of head), physical traits presumably relatively unaffected by environmental factors, Pearson [17] found marked resemblances among members of the same family. The physical resemblance averages approximately .50 in terms of the coefficient of correlation.[18] (Table 7.)

would be much more criss-crossing of the lines and the final coefficient would be lower. A coefficient of 0.00 represents chance correlation. The per cent better than chance correlation of various coefficients may be expressed as follows:—

.10	½ %	.70	29 %
.20	2 %	.80	40 %
.30	5 %	.90	56 %
.40	8 %	.95	69 %
.50	13 %	.98	80 %
.60	20 %	1.00	100 %

The method for calculating coefficients of correlation illustrated above is only one of a number which may be used for this purpose. However, in all cases, a *minus* sign before the coefficient indicates that the relationship is in opposite directions.

The reader is referred to texts in statistics for a further discussion of methods employed in calculating the coefficient of correlation. The student should also become familiar with the principles to be applied in interpreting the significance of a coefficient of correlation. It is important for him to know that the coefficient of correlation is unreliable if its value is less than 4 times that of its Probable Error (P.E.). He should understand the effect of the homogeneity of the group, of unreliable raw data, of spurious factors, etc., upon the coefficient of correlation. The student must again be referred to statistical texts for such information. However, because of the basic importance of the P.E. of the coefficient, and inasmuch as this is often omitted by investigators in stating results, there is given below a brief table of the values of Probable Errors for coefficients of correlation of stated values for given numbers of cases.

Probable Errors of the Coefficient of Correlation for Various Numbers of Measures (N) and for Various Values of r (Coefficient of Correlation)

No. of Measures	Correlation Coefficient (r) 0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
20	1508	1493	1448	1373	1267	1131	0965	0769	0543	0287
50	0954	0944	0915	0868	0801	0715	0610	0486	0343	0181
100	0674	0668	0648	0614	0567	0506	0432	0345	0242	0128
200	0477	0472	0458	0434	0401	0358	0305	0243	0172	0091
500	0302	0299	0290	0274	0253	0226	0193	0154	0109	0057
1000	0213	0211	0205	0194	0179	0160	0137	0109	0077	0041

[16] R. Pintner, *Intelligence Testing*, New York, 1931, p. 507. Italics by the author.
[17] K. Pearson, "On the Laws of Inheritance in Man," *Biometrika*, 3 (1904), pp. 131–190.
[18] *Ibid.*, p. 160.

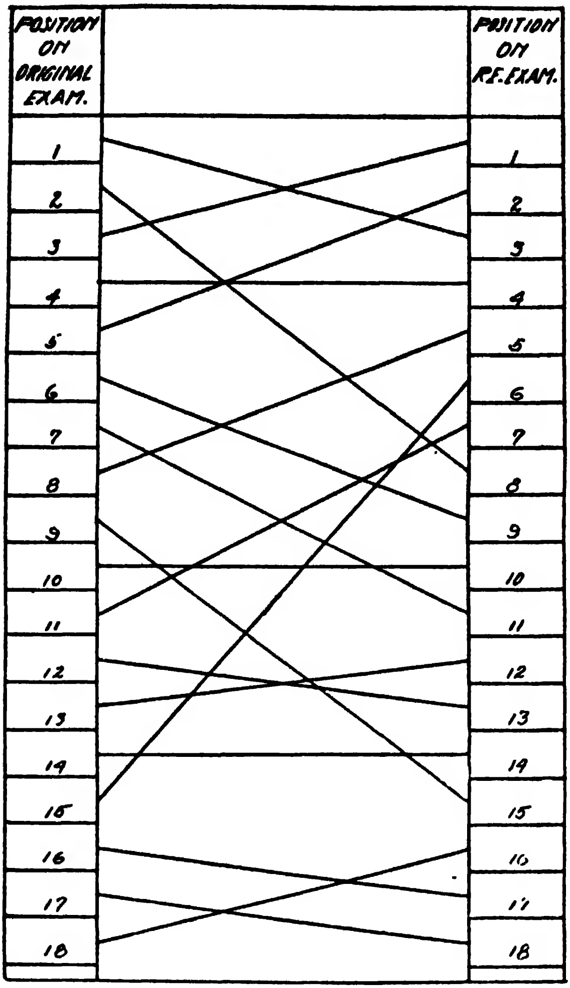


FIGURE 12. *Position of 18 Employees on Re-examination. Series A and B as Compared with Position on First Examination*

(*After Viteles*)

Pearson also used estimates of mental traits such as *vivacity, self-assertiveness, ability, conscientiousness,* in comparing brothers, and brothers and sisters (siblings), and concludes from an examination of the average coefficient of correlation (.50) that the effect of heredity upon mental characteristics is apparently the same as upon physical characteristics.

In more recent studies tests instead of estimates have been em-

TABLE 7

Coefficients of Correlation on Trait Relationships (Pearson)

Color of eyes	brothers	.52
Height	brothers	.50
Height—father and son		.30
Cephalic index	brothers	.49
Color of hair	brothers	.55

ployed in studying sibling and parent-child resemblances as an aid in evaluating the contribution of heredity in producing individual differences.[19] From a comparison of educational and psychological test scores obtained by 18 pairs of siblings, aged 19 to 32, attending the University of Wisconsin, Starch[20] concludes that "the resemblance of siblings is apparently no greater in those mental traits which are directly affected by school work than in those which are not so affected. This seems to indicate that the mental similarities of children of the same parents are due primarily to heredity rather than to similarity of environment, since the resemblance is no greater in those traits which are more directly affected by environment." From a study of brothers and sisters in a public school, supplemented by re-examinations at the end of a year and a very careful analysis of data, Thorndike[21] concludes that the resemblance in intelligence of unselected siblings is slightly greater than that found by Pearson[22] for physical traits. The difference in the value of the two coefficients of correlations is assumed by Thorndike[23] to represent the slight "influence upon intelligence of such similarity in environment as is caused by being siblings 2 to 4 years apart in an American family." Jones[24] tested 527 individuals, in 105 families, in which there were both parents and two or more children, in a stable New England settlement offering a relatively constant environment for a native born group of native parentage. In this investigation there was found a tendency, where parents were unlike in intelligence, for the child's Intelligence Quotient to

[19] In the development of the section which follows, the author refers to many studies in a report on "Nature and Nurture" forming the *27th Year Book*, of the National Society for the Study of Education, Bloomington, Ill., 1928, Part I, pp. 465; Part II, pp. 397. This combines an excellent survey of earlier studies with important original studies. Earlier studies are briefly summarized in an article by B. S. Burks, Part II, pp. 248–353.

[20] D. Starch, "The Similarity of Brothers and Sisters in Mental Traits," *Psych. Review*, 24 (1917), pp. 235–38.

[21] E. L. Thorndike, "The Resemblance of Siblings in Intelligence," *27th Yr. Book*, Nat'l Soc. for the Study of Ed., Bloomington, Ill., 1928, Part I, pp. 41–53.

[22] Pearson, Physical Traits + 0.52.

[23] Thorndike, Intelligence + 0.60

[24] H. E. Jones, "A First Study of Parent-Child Resemblance in Intelligence," *27th Yr. Bk.*, Nat'l Soc. for the Study of Ed., Bloomington, Ill., 1928, Part I, pp. 62–74.

strike the medium, the inferior and superior parents having equal influence in determining the intelligence of the child.

Another interesting contribution to the data on resemblance of siblings is provided by May and Hartshorne.[25] Seven hundred and thirty-four pairs of siblings, scattered among 7 schools, including 2 orphanages, were measured with 4 different types of deception tests.

Behavior A.—In one type of class room situation, the pupils deceive by adding more scores to a speed test after time is called. The amount which any score is thus illegitimately increased beyond what it would otherwise be is taken as a measure of deceit. There are six of these tests affording six opportunities to cheat. The total amount of dishonest increase is reckoned as the total score in this battery.

Behavior C.—In this type of situation the pupil deceives by copying from a key or answer sheet and thereby increases his score on some school test beyond what he could achieve without such assistance. Three intelligence tests are used in this battery and the total dishonest increase is taken as the total deception score.

Behavior P.—This battery consists of three "peeping" tests with techniques adapted from Voelker and Cady. The pupil deceives by opening his eyes, or "peeping," when the directions call for doing the test with eyes closed. The total amount done over and above what could be done with eyes shut is the total score.

Behavior H.—This consists in securing help on a test taken at home, after being definitely instructed not to get any help from any source. Deceit consists in getting help. The amount is determined as in the case of Behavior C.

An analysis of the results showed that siblings resemble one another in deception, whether the opportunity to cheat was offered at home or at school. According to the authors this resemblance "cannot be adequately explained by the social status of the homes in which the children are reared. After cancelling the environmental factors, there seems to be left, in the case of deception, a degree of sibling similarity as great as that discovered by the best intelligence tests; that is, it seems as likely that deception is biologically conditioned as it does that intelligence is biologically conditioned."

The final determination that deception is an inherited trait, little subject to modification of environment, will, of course, have an enormous significance for industry, which faces the problem of predicting the honesty of prospective employees in many situations and their susceptibility to change in these situations. The results of May and Hartshorne's study are far from conclusive, even for siblings; they cannot be transferred bodily to adults in industry, but they suggest the wide implications for industry of this problem of nurture and nature.

c. *The Comparison of Twins*

The study of the parent-child and sibling relationship has been supplemented by the comparison of twins. This type of study was started by Galton,[26] who cites many interesting examples of marked similarities obtained by sending questionnaires to twins and to their relatives. In later studies more exact methods have been employed in the comparison of mental traits of both identical and non-identical twins. The classic experiment of this type is that of Thorndike [27] who applied 6 tests, involving the cancellation of A's on a printed page of capital letters, a misspelled word test, tests of addition, multiplication, etc., to 50 pairs of twins from 9 to 14 years of age. The conclusion is drawn that the amount of resemblance of twins on mental tests is approximately twice that of ordinary siblings. The author also finds that young twins of the group are as much alike as the older ones, and that the resemblance is as strong in relatively untrained capacities as in trained ones. He therefore concludes that the similarities are due to inborn capacities, that "the nature of germ cells—the conditions of conception—cause whatever similarities and differences exist in the original natures of men, that these conditions influence body and mind equally, and that in life the modifications of body and mind produced by such differences as obtain between the environments of present day New York public school children are slight." [28]

A later investigation by Merriman [29] yields similar findings and conclusions, although the significance of the latter is questionable by reason of certain technical errors in the treatment of data. One hundred and fifty-eight pairs of twins and 199 children, members of 72 families in public and private schools in New York, were tested by Tallman.[30] The average difference in intelligence quotient between siblings is found to be 13.1; between non-identical twins 7.3; and between identical twins 5.0. In other words, the difference between siblings is found to be about twice as great as that between all twins (7.0). "It remains to argue," it is pointed out, in a critical note on this study, "that such results might still be thought of as due to similar degrees of closeness of environment, rather than as due to inherited constitutional dispositions, but such an argument certainly seems too far fetched to be taken very seriously, inasmuch as it would have to be assumed, for instance, that the environment is distinctly more nearly the same for identical than for non-identical twins."

[26] F. Galton, *Inquiries into Human Faculties*, London, 1883, pp. 387.
[27] E. L. Thorndike, "Measurement of Twins," *Phil. and Psych.*, 13 (1905), p. 64.
[28] E. L. Thorndike, *Educational Psychology* (*Briefer Course*), p. 367.
[29] C. Merriman, "The Intellectual Resemblances of Twins," *Psych. Monograph.*, 32 (1924), pp. 58.
[30] G. G. Tallman, "A Comparative Study of Identical and Non-identical Twins with Respect to Intelligence Resemblances," *27th Yr. Book*, Nat'l Soc. for the Study of Ed., Bloomington, Ill., 1928, Part I, pp. 83–88.

In addition to these mass statistical studies there have appeared a number of specialized studies of single pairs of twins which are of some interest from the viewpoint of this general problem. Among these are Newman's [81] and Müller's [82] studies of identical twins reared apart, and Koch's [83] study of a pair of Siamese twins. An example of another approach to the study of this general problem of heredity, by the investigation of twins, is to be found in Lange's [84] investigation of the lives of 30 pairs of identical and non-identical twins of which at least one was in prison at the time the study was made. Of the 13 pairs of identical twins in 10 cases both members of the pairs had been in prison, whereas among the 17 non-identical pairs only in 2 cases had both members been in prison. The criminality in non-identical twins was not higher than that of ordinary brothers and sisters. The detailed reports about the life of the identical twins reveal an extraordinary likeness of these twins with regard to their conflicts with the penal code. The author cites these findings as evidence of the decisive rôle of the genetic constitution in human conduct.

A summary of available findings of statistical studies on the amount of resemblance among related and unrelated individuals is presented by Pintner in the form of coefficients of correlation of the values shown in Table 8.[85]

TABLE 8

Coefficients of Correlation

Identical twins	.90	Siblings	.50
All twins	.75	Cousins	.20
Fraternal twins	.70	Unrelated individuals	.00

(After Pintner)

"And this," according to Pintner, "is exactly the hierarchy we would expect to find, if heredity were an important factor in intelligence. At the same time these findings are no proof of the inheritance of intelligence, because this hierarchy of coefficients corresponds also to the degree of similarity of environment usually found among the various groups of individuals. All that we can claim is that our calculations agree perfectly with the hypothesis that intelligence is inherited in the same way as physical characteristics are inherited."

d. *The Social and Economic Status of Parents*

Another approach to the evaluation of the contribution of inheritance is found in studies of the intelligence of children in relation to the occupations of their fathers. In such investigation two assumptions are usually made:

(1) that professional level is determined largely by mental status, and

(2) that the descending hierarchy of averages in intelligence of children corresponding with the hierarchy of occupational levels of parents (from the professions to unskilled labor) represents the influence of heredity.

Those in the higher grade occupations are assumed to have succeeded by reason of superior intelligence, which they transmit to their children. Characteristic of the findings of this type of investigation are the percentages of high school children scoring above the group medians on an intelligence test, in comparison with the occupations of their fathers, shown in Table 9.[36]

TABLE 9

OCCUPATION OF FATHER	PERCENTAGE OF CHILDREN SCORING ABOVE GROUP MEDIAN
Professional	60
Clerical	60
Salesman	56
Artisan	55
Executive	54
Day Laborer	47
Farmer	43

(After Book)

The occupational distribution of the fathers of superior children included in Terman's main study of genius was found to be 31.4 per cent professional, 50 per cent semi-professional and business, 11.8 per cent skilled labor, 6.6 per cent semi-skilled labor, 0.13 per cent common labor.[37] The percentages are tremendously weighted in favor of the superior occupational class. The author accepts this and the fact that differences among individuals appear in early childhood as evidence that the "causal factor lies in original endowment rather than in environmental influences." The fact that such differences do occur in early age is confirmed by Goodenough in a study of pre-school children.[38] In this

appears a range from an average Intelligence Quotient of 96 for children of unskilled laborers to 125 for children whose fathers are in professional occupations. "The value of the pre-school results," according to Pintner, "is to show that these differences in I.Q.'s of occupational groups are not caused by education. They exist in marked degree even before the child comes to school." [39]

The existence of similar differences, running parallel to occupational status, is reported from English investigations by Duff and Thomson,[40] by Jones and Carr-Saunders [41] as well as in American studies. The Jones and Carr-Saunders study is of particular significance because of the relative constancy of the environment of the orphanage children who served as subjects of the investigation. The enriched surroundings of children in socially superior homes, in contrast with the limitations of the poorer homes, may very easily contribute to the superiority of the former on the standard intelligence tests. The fact that home environment is constant for the orphanage children in the Jones-Carr-Saunders study strengthens the validity of the conclusion "that there is no reason to suppose, so far as this evidence is concerned, that environmental influences are the whole or even the major part of the cause of the differences in intelligence between children of different social origins."

2. Contribution of Environment

a. *General Studies*

The investigations so far discussed have been oriented primarily from the viewpoint of heredity—designed to reveal the part played by nature in giving rise to individual differences. In addition to this is a group of studies organized with the specific purpose of revealing the effect of changed environment upon variability of individual mental traits. The most significant of these are two investigations conducted independently by a University of Chicago group and by a group from Stanford University. The two studies, employing somewhat different methods, were undertaken to gather evidence upon almost identical problems. Both deal with the influence of home environment upon the mental development of children. The Stanford study offers, in addition, evidence upon the influence of heredity.

The chief problem of the Chicago investigation [42] was to determine

methods—that heredity is a force in the determination of mental ability by the side of which all other forces are 'dwarfed in comparison.'" [44]

The two studies agree in assigning a definite rôle to environment in producing differences in ability and achievement. There is a disagreement as to the extent of its influence. The Chicago study appears to attach a somewhat greater significance to environment. However, it must be recognized that the influence of heredity and environment respectively will vary with the character of the population studied, its variable social standards, educational opportunities, degree of selectivity, etc. Differences in these factors between the two groups studied may account for quantitative differences in findings which, however, show general agreement with respect to the measurable influence of environment upon the development of individual intelligence. An analysis of the disagreements by Burks [45] leads her to conclude that the implications of the Chicago findings are, in effect, closer to those of the Stanford study than appear on the surface.

b. *The Study of Specific Influences*

The final solution of the nature and nurture problem is probably to be found in major studies such as those of Freeman and Burks in which the influence of heredity and environment can be separately studied by making the other relatively constant. At the same time, valuable contributory supplementary data is to be found in the analysis of specialized traits such as "mechanical ability" and "musical talent," and in studying the effect of special conditions such as school achievement, training, or practice upon the development of mental traits.

Among investigations of the former type is the work of Anderson [46] in studying the relationship of environmental factors to measures of "mechanical ability." Anderson obtained detailed information on the cultural and mechanical environment of 135 boys by means of a questionnaire filled out in part by a trained social worker and in part by the parents of the boy. Seven sets of environmental factors were covered in this questionnaire.

1. *Cultural Status of Family*
2. *Literary Interests*
3. *Recreational Interests*
4. *Mechanical Operations of Father*
5. *Mechanical Operations of Son*
6. *Tools Owned by Father*
7. *Tools Owned by Son*

[44] *Ibid.*, p. 309.

[45] B. S. Burks, "Comments on the Chicago and Stanford Study of Foster Children," *27th Yr. Bk.*, Nat'l Soc. for the Study of Ed., Bloomington, Ill., 1928, Part I, pp. 317–21.

[46] L. D. Anderson, "The Relationship of Certain Environmental Factors to Measures of Mechanical Ability," *27th Yr. Book*, Nat'l Soc. for the Study of Ed., Bloomington, Ill., 1928, Part. II, pp. 137–152.

To determine the relation of environmental factors to mechanical ability, the seven aspects of the environment were correlated with two mechanical shop criteria, or scores in mechanical success. The shop success scores indicated (1) success in manipulation of tools and materials, and (2) amount of information acquired about tools and materials. In measuring manipulative skill, projects made by the boys were subjected to objective measurement on many well-defined and specific parts. These measurements were combined to give a general measure of manipulative success in the type of shop work covered by junior high school courses in sheet metal work, woodwork, electricity, printing, and mechanical drawing. The amount of information acquired in each of these shops was measured by multiple-choice information tests given at the end of the course, the scores of which were combined to give a general measure of "shop information." The correlations between the environmental aspects and the shop success measures are given in Table 10.[47]

TABLE 10

The Correlations of the Seven Environmental Factors with the Measures of Manipulative and of Informational Standings in Mechanical Lines (100 cases)

FACTOR	CORRELATION WITH MANIPULATIVE CRITERION	CORRELATION WITH INFORMATIONAL CRITERION
Cultural status of Family	— .07	.01
Literary interests of son	.13	.22
Recreational interests of son	.01	.12
Mechanical operations of father	.09	.24
Mechanical operations of son	.30	.35
Tools owned by father	.01	.11
Tools owned by son	.10	— .02

(After Anderson)

All of the correlations are low. The measures of mechanical environment show slightly higher relationship with mechanical ability than do those of non-mechanical environment, but the coefficients are too low to warrant the conclusion that mechanical shop success is substantially related to any of the aspects of the environment measured by the questionnaire. An incidental observation made in the course of the study is that a high cultural (economic) status of the family is not conducive to the ownership of tools by either father or son, or to the doing of many mechanical operations by either. The mechanical "opportunities" of boys tend, under such circumstances, to be restricted by either a

[47] *Ibid.*, p. 147.

large family income or by unwise budgeting of family expenditures.

The results of this study indicate, in general, that little or no influence can be attributed to the mechanical activities of a boy's father, the tools which the boy's father owns, or the cultural status of the home upon the boy's mechanical ability when this is judged by ratings upon actual projects made in school shops, tests of "shop information" at the close of shop courses, and scores on eight standard mechanical tests. *The absence of any measurable influence from these environmental factors leads to the surmise that the undoubted differences that exist in mechanical ability are mainly innate.*

Interesting data on the inheritance of "musical ability" is presented in an article by Farnsworth [48] who contrasts Seashore's [49] assertion that "musical talent is a gift bestowed very unequally upon individuals —that is inborn only in specific types" with the opinion of Stern [50] that "musicality" may be acquired. Stanton's [51] findings in a comparison of discrimination of pitch, intensity, time, and tonal memory of 85 parents and offspring, supplemented by a systematic survey of musical environment, are offered in evidence of the influence of heredity. Reference is also made to the study, by Voss,[52] of a musician with two wives—one musical and one unmusical. A follow-up of seventeen children, in five succeeding generations, revealed the existence of two strains, one musical and the other non-musical associated with respective wives. Direct evidence on the influence of environment on musical ability is more limited. Although available data seems to favor the predominating influence of heredity, Farnsworth's conclusion that the "question of musical heredity is still a moot one" seems on the whole justifiable. The problem is complicated by difficulties in testing, by wide variation in opportunities for training, and by similar factors which help to create an intricate confusion of cause and effect.

c. *The Effect of Training on Individual Differences*

Among problems on the origin of individual differences of major interest to the student of industrial psychology is the question of the effect of training on individual differences. It is important, for example, to know if an applicant who makes a low score on a test of "mechanical ability" at the time of employment can be expected to improve his score following practice on a job calling for manipulative tasks involving "mechanical ability." From the viewpoint of produc-

[48] P. R. Farnsworth, "The Effect of Nature and Nurture on Musicality," *27th Yr. Book*, Nat'l Soc. for the Study of Ed., Bloomington, Ill., Part II, pp. 233–45.

[49] C. E. Seashore, *The Psychology of Musical Talent*, Boston, 1919, pp. 288.

[50] W. Stern, *Die Differentielle Psychologie*, Leipsig, 1911, pp. 265.

[51] H. M. Stanton, "The Inheritance of Specific Musical Capacities," *Psychological Monographs*, 31 (1922), pp. 157–204.

[52] G. Voss, *Deutsche Zeitschrift fur Nervenkrankheiten*, 83 (1925), pp. 249–63. Cited from P. R. Farnsworth, *op. cit.*, p. 236.

tion it is of utmost importance to know whether the lowest of 10 workers in production during the first week of employment will continue to remain at the bottom or close to the bottom of the list or whether, as a result of practice, he is liable to reach or exceed the level of workers with better production records during the first week of employment. Assuming even that other *general* environmental conditions play but a minor rôle in the development of a trait, the influence of systematic training may be marked enough to remove or reverse the direction of difference existing within a group prior to intensive training.

The experimental investigation of the effect of practice has much to contribute to the nature-nurture controversy. "If individual differences can be eliminated by training then they are presumably largely due to environmental factors. If they persist, in spite of equalized training, they are presumably to be attributed to nature rather than nurture." [53] In addition, this problem is fundamental in the formulation of a sound personnel program—in determining, for example, the rôle to be assigned to scientific selection in contrast to that assigned to training in promoting individual efficiency and adjustment in industry. If differences cannot be wiped out by training of even the most intensive sort, scientific selection as an aid in properly sorting and placing applicants for employment assumes the major position in the personnel program. If the reverse is true, selection may become a mere formality, a gross sorting process for the elimination of those unsuited for reasons other than deficient ability, with a feeling of assurance that suitably organized and administered training programs will bring all up to the same level of productive efficiency, regardless of differences appearing in the early period of service in the department for which the applicant may be employed.[54]

In so far as the effect of practice is concerned, both common observation and laboratory experimentation show that improvement follows training or practice in almost every kind of performance. A major problem in psychology is to determine whether such improvement represents a *bonafide* betterment of "innate capacity," or merely an acquisition of certain information and techniques of value in its operation. If the former is true, heredity and "original nature" lose their potency in determining individual advancement and environment and formal training take on almost unbounded power in the improvement of the individual. If the latter is the case, it can be concluded that the individual can only learn, through the application of improved knowl-

[53] Prefatory Note to Chapter 14, *27th Yr. Book*, Nat'l Soc. for the Study of Ed., Bloomington, Ill., 1928, Part II, p. 210.

[54] The general aspects of this problem are considered in this chapter. The specific influence of training on "skill" is discussed in Chapter XII, in considering the relationship between "educability" and testing procedures in industry.

edge and technique, to use to better advantage the traits which he possesses, but cannot hope to rise above a level established by the hereditary forces which have contributed to his being.

Early experimental results in this field are somewhat contradictory in character. In laboratory studies, with adults as subjects, on the development of range of visual apprehension of groups of letters, dots, drawings, etc., exposed to view very briefly, Whipple [55] and Foster [56] found no improvement of any basic intrinsic ability. A slight improvement which did occur was attributed to "tricks" and techniques acquired during the course of the experiment. Dallenbach,[57] employing the same procedure with third grade school children as subjects, not only discovered a marked practice effect, but also concluded that the practice led to permanent alteration and modification of certain mental traits. However, Oberly [58] concluded from a later experiment with adults that increase in number of digits apprehended as a result of practice is due to an improvement in method of grouping and not to an improvement in fundamental ability.

In a more recent experiment by Gates [59] an attempt was made to determine the exact character of improvement with practice. With 82 children, 4 to 6 years of age, as subjects, the investigator studied the improvement in rate of tapping with a blunt pencil. The subjects were given daily 3 short practice periods in tapping for 18 days. At the beginning of the experiment they were also tested once on 8 different motor functions requiring speed of decision and control. At the end of 18 days of practice in tapping, the pupils were paired so as to yield two groups practically equivalent in each of the following respects: (1) *Speed of Tapping,* (2) *Motor Ability on the 8 Tests,* (3) *Sex,* (4) *Chronological Age,* (5) *Stanford-Binet Mental Age,* (6) *Intelligence Quotient,* (7) *Grade in School.* For one group the training was stopped, but with the other it was continued. The pupils in the latter group were given 3 short practice periods per day, while working in groups of 5 to 8, for 76 days over a period of 6 months. Then, during a final period of 17 days, both groups were given practice. The progress of both groups is shown in Figure 13.

"These figures indicate a fairly rapid rise in tapping ability during the first 18 days, suggestive of the acquisition of various devices and techniques. For the Practice Group there is a slow but steady improvement during the next six months of practice. Tested again after

[55] G. M. Whipple, "The Effect of Practice upon Range of Visual Attention and of Visual Apprehension," *J. Ed. Psych.*, 1 (1910), pp. 249–62.

[56] W. S. Foster, "The Effect of Practice upon Visualizing and upon Reproduction of Visual Impressions," *J. Ed. Psych.*, 2 (1911), pp. 11–21.

[57] K. M. Dallenbach, "The Effect of Practice Upon Visual Apprehension," *J. Ed. Psych.*, 5 (1914), pp. 321–334, 387–404.

[58] S. H. Oberly, "Range of Visual Attention and Apprehension," *Am. J. Psych.*, 35 (1924), pp. 332–52.

[59] A. I. Gates, "The Nature and Limit of Improvement due to Training," *27th Year Book,* Nat'l Soc. for the Study of Ed., Bloomington, Ill., 1928, Part I, pp. 441–460.

this period of no practice, the untrained or Control Group is slightly less proficient than the Practice Group. The Control Group very rapidly improves, however, so that after the 103rd day they are quite equal to the Practice Group." [60]

At the expiration of another 6 months without practice both groups were again given 3 trials daily for 6 consecutive days. They were

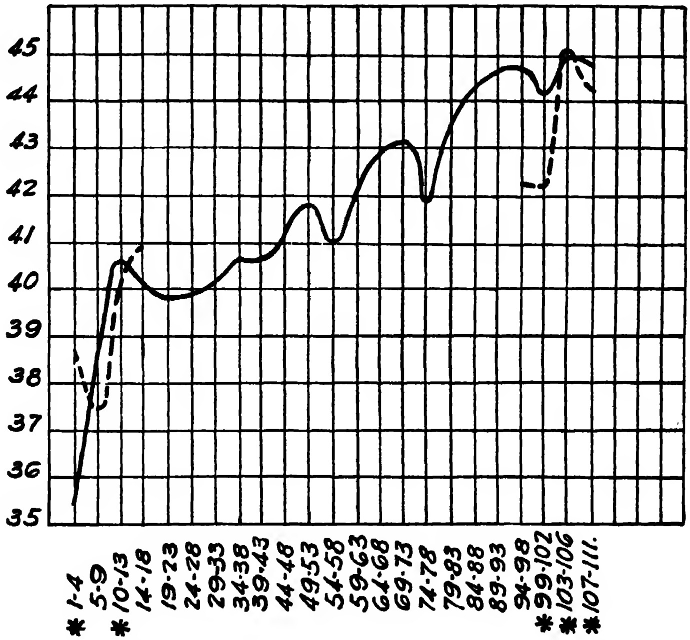


FIGURE 13. *Average Scores in Tapping, Arranged by Five-Day Periods (Except the Starred, Which are Four-Day Periods) (After Gates)*

shown still to be practically alike in rate of tapping at the end of the period. In addition, the 8 motor tests were repeated at the end of 6 months of practice and of 6 months of rest. On these tests both groups made substantially the same average improvement.

The fact that the Practice Group was no better after nearly 6 months of continuous practice than the Control Group after a few days of re-adjustment suggests that in this simple motor task improvement was due to technique and that practice had no perceptible influence upon capacity. It seems probable that increased rate of tapping is due to improved technique for taking the tapping test rather than to a steady increase in any fundamental capacity for tapping. Another significant feature of this study is that individuals in the groups differed in tapping

[60] *Ibid.*, p. 451.

ability not only before practice was begun but after maximum efficiency had been attained by dint of intensive and long-continued training.

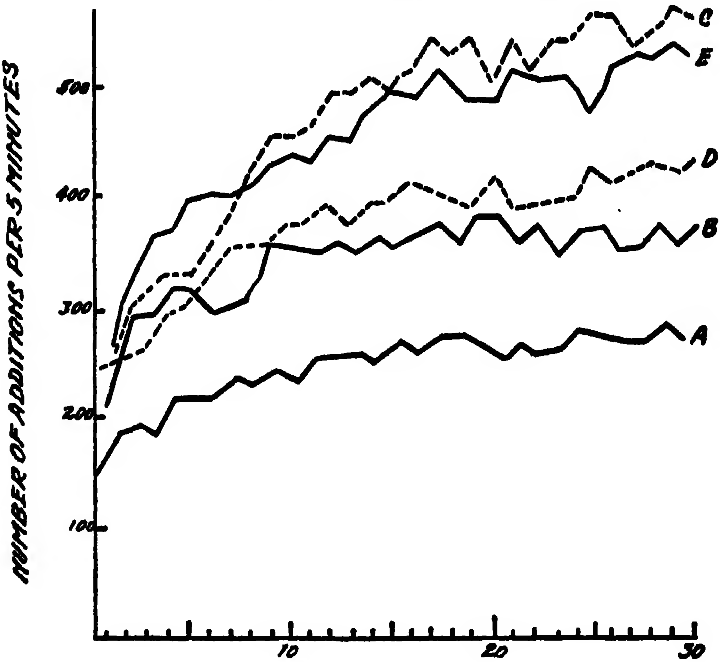
In a supplementary experiment by the same investigator, involving a "mental" function, immediate memory for digits, with approximately the same conditions as the first experiment, the Practice Group did show a superiority over the Control Group after 5 months of continued practice. However, after a lapse of another 4½ months without practice the groups made almost identical results. In other words, whatever advantage had been gained by the first group as a result of practice was not permanent. The studies, as the author indicates, reveal the apparent futility of training beyond a certain amount to produce an improvement of performance. The effect of training appears to be not to change directly or modify the growth of *capacity*, i. e., the functional possibilities of the mechanism, but, through the superimposition of useful information, techniques, methods of work upon capacity, to increase to a limited extent the *proficiency* of the individual. The conclusions obviously reinforce the position of those who believe that the fundamental endowments given by nature are themselves little open to alteration.

The analysis of the general question of whether improvement takes place with training and the nature of such improvement has been supplemented by investigations designed to determine whether individuals in a group who are least efficient at the beginning tend to be least efficient throughout a period of practice or vice versa. Associated with the question of changes in relative rank during practice is that of whether practice in a specific activity increases or decreases the amount of difference present in a group, that is, whether it narrows the range between the poorest and best, or increases it so that after training the best more than ever outshine the poorest. Investigations on these questions as they affect procedures to be used in testing in the industrial situation are discussed in Chapter XII. One or two experiments of a general nature may be cited here in order to illustrate the problems involved.

Early studies by Thorndike lead to the conclusion that the individual whose position in the group is low at the beginning of a training or practice period generally maintains his place in the low part of the group when every member of the group is given exactly the same kind and amount of practice or training. Individuals starting at a relatively high level maintain their high position in the group. This is clearly illustrated in Figure 14, showing the improvement in addition of one-place numbers on the part of 5 adults during five-minute periods of 30 successive days of practice. A and B, starting with the lowest number of additions in the first five-minute period, remain low; C, D, and E, although changing positions with each other, continue to complete more additions in five-minute periods on each of the 30 days of practice than do A and B. Similar results are found in extensive experiments with activities ranging from motor performances such as ball

tossing, card sorting, and marble sorting to the more specifically mental operations of routine completion, calculation, answering questions of fact from history, etc.

A more recent experiment by Hartmann [61] furnishes further evidence



AMOUNT OF PRACTICE: IN DAILY PERIODS OF 5 MINUTES. IMPROVEMENT IN ADDITION OF ONE-PLACE NUMBERS: FIVE ADULT WOMEN
AFTER WELLS, '12, PLATE II, FOLLOWING P. 82.

FIGURE 14

along the same line. In this 50 subjects took part in an experiment which involved (1) "the repetition of the alphabet as rapidly as possible *forward,* i. e., A-B-C; (2) the interception of the letter 'n' between each pair of the letters, i. e., AnBnCn; (3) the repetition of the alphabet as rapidly as possible *backward,* i. e., Z-Y-X; and (4) the repetition of the alphabet backward intercepting 'n' between each pair of the letters, i. e., ZnYnXn." Twenty trials were made on each of the 4 series, records being taken twice daily. The correlations between the average time for the first and last trial are shown in Table 11. On the strength of these values the author concludes that "even in such a

restricted capacity as reversed alphabetization most subjects adhere to the level of achievement they have struck at the start." [62]

TABLE 11

SERIES	CORRELATION BETWEEN INITIAL AND FINAL MEANS	PROBABLE ERROR (N = 50)
I	.78	.03
II	.43	.08
III	.64	.05
IV	.56	.06

(After Hartmann)

In contrast with these findings are the results of a recent experiment by Ehinger.[63] This involved the investigation of the effect of manual work upon performance in 4 tests of manual ability. The subjects include (I) 25 students in a pre-apprentice class, tested during the first week of apprenticeship, and again after a lapse of 5 months; (II) 88 workers, aged 14 to 30 years, tested prior to employment and after 3 months to a year subsequent to employment; (III) a control group of 54 pupils of the same age as the apprentices; and (IV) adult workers employed in a factory for at least 7 years, examined twice at 3-month intervals. The author finds that the second test performance is in every instance superior to the first, but that the children in the control group show less improvement than the apprentices, although re-tested after a shorter interval. However, *there is relatively more improvement in the case of those testing low on the first performance than in the case of those testing high.*

With respect then to the question of how practice affects the degree of resemblance of the members of a group there is wide difference of opinion. According to some, practice tends to promote the heterogeneity of a group, i. e., to separate more widely the performance of the least competent from that of the most competent. This would naturally follow if the effect of practice varies directly with the degree of the capacity—the least capable actually profiting less from training than the most capable. Under such conditions the haphazard selection of workers from the entire range of the distribution would result in a growing divergence in production on the part of members of the group through successive weeks of practice on the job of the type shown in Figure 14. An alternative viewpoint is that practice increases the degree of resemblance among the members of a group as a result of the

fact that the less competent profit to a greater degree from training than the more competent. It is also possible, as Peterson [64] has suggested, that "subjects of normal heterogeneity would become more alike with practice on the simpler processes or activities but more different on the more complex activities." The significance of such a conclusion from the viewpoint of industrial adjustment has been well stated by the same author: "If all vocational activities were arranged in a series from the simplest to the most complex, there would be a point in the series for a given individual, with given abilities, below which we could advise him to choose his line of vocational activities if he would hold his own in competition with others. Industrious practice in an activity below this point would be rewarded by his becoming more and more like the most practiced." [65] However, neither Peterson's own results nor those of other investigators confirm this compromise position. At the moment the applied psychologist can merely accept the facts, developed in controlled experiments, that as a result of practice individuals generally become more and more alike in mental multiplication and more and more unlike in addition; more unlike in mathematical calculation than in the acquisition of history and language information; that in intellectual activities there generally appears to be more frequent occurrence of divergence with practice than in such physical activities as ball tossing and javelin throwing. Awaiting a final solution of this problem the psychologist must avoid generalization and determine under controlled conditions the effect of practice on resemblance among the members of a group with respect to the specific performance in which he may be interested.

3. GENERAL CONCLUSIONS CONCERNING THE INFLUENCE OF HEREDITY AND ENVIRONMENT

The formulation of generalizations from varied data on the influence of heredity and environment is fraught with many difficulties, both technical and interpretive. The varied character of the findings themselves, the technical weaknesses and the difficulties of interpretation suggest extreme caution in drawing final conclusions on the relative contribution of heredity and environment in the explanation of human variability. The formulation of hard and fast conclusions may perhaps reasonably furnish occasion for criticism of a type which Gilbert has so charmingly embodied in his observation that:

"Headstrong youths
Of decent education
Determine all important truths
With strange precipitation.

[64] J. Peterson, "The Effects of Practice on Individual Differences," *27th Yr Book*, Nat'l Soc. for the Study of Ed., Bloomington, Ill., 1928, Part II, pp. 228–229.
[65] *Ibid.*, p. 229.

The over-ready victims they
Of logical illusions
And in a self-assertive way
They jump at strange conclusions."

At the same time the data seems to have a definite bearing and to permit the following broad, and perhaps tentative, generalizations as to the influence of nature and nurture in giving rise to individual differences:

1. Variability in the human race results from the interaction of heredity and environment. Neither nature nor nurture alone can explain the wide range of differences in mental traits so characteristic of the race.

2. Heredity appears to be the determining factor in accounting for individual differences. It seems to set up in a very definite way the limit of development on each trait which characterizes the individual. Not even the most favorable environment will convert the congenital idiot into an adult of average attainment.[66] Heredity rather than environment appears to account for the attainment of men like Lincoln, Carlyle, Dickens, who literally "raised themselves by their bootstraps" above the restrictions of impoverished surroundings.[67]

3. Environment as a general force does, however, make a very definite contribution to human variability. Its chief effect may be described as restrictive in character. The depressing effect of a limited environment seems more marked than the stimulating effect of an enriched environment. Although the mediocre individual cannot be raised to the level of the genius by his surroundings or opportunities, the slightly superior individual may never function above the level of mediocrity if his environment fails to furnish adequate stimulation for the development of his capacities.

In so far as positive effect is concerned, there seems no justification for Watson's assertion,[68] quoted on an earlier page, that by providing a suitable environment he can make to order, at will, a butcher, a baker, a candle-stick maker, aye, even a philosopher and a biologist.

4. Organized training or practice definitely raises the level of proficiency at which a capacity functions. The burden of available evidence suggests that training does not destroy individual differences or materially change the rank of an individual in comparison with those around him. It is impossible to generalize on whether practice increases or decreases the degree of resemblance, i. e., the variability within a group.

[66] B. S. Burks, "The Relative Influence of Nature and Nurture upon Mental Development," *27th Yr. Book*, Nat'l Soc. for the Study of Ed., Bloomington, Ill., 1928, Part I, p. 308.

[67] It is possible, as has been suggested by some investigators, that what appears to be the influence of heredity represents merely "sets" established in early infancy. However, available evidence does not favor such a generalization.

[68] J. B. Watson, *op. cit.*, p. 32.

4. SIGNIFICANCE OF THESE CONCLUSIONS FOR INDUSTRIAL PSYCHOLOGY

These general conclusions on the origin of individual differences have a tremendous significance for the application of psychology in industry.

1. In the first place, they justify the use of highly refined procedures in the selection of workers to determine the inherent strength and weakness of the applicant for employment. There can be no expectation of a fundamental change in the capacities of a mature or nearly mature individual selected for a job. His happiness, his success or failure on the job depend primarily upon a combination or pattern of native abilities, present at the time of employment, which are little, if at all, subject to change. These facts also make necessary a supplementary analysis of individual capacity in every instance of transfer or promotion to a job involving a change in duties and of qualifications. The determination of individual capacity is basic to individual adjustment in industry.

2. The fact that performance of individuals at every point in the range of capacity improves with practice points to the importance of systematically organized training programs designed to promote the most effective use of the capacity of every individual in the industrial plant. These training programs will furnish systematic instruction in such improved techniques and supplementary information as is needed for the complete utilization of individual capacity.

3. The restrictive effect of environment upon the maximum use of capacity makes necessary a thorough study of working conditions in the industrial plant. The objectives of such a study are the elimination of conditions of work which may interfere with the full and easy use of capacity, and the substitution for them of conditions favorable to the attainment of maximum proficiency and adjustment.

SECTION TWO

FITTING THE WORKER TO THE JOB

VIII. BASIC FACTORS IN VOCATIONAL SELECTION

> "My feeling about the fundamental policy of employment is that we often stop short in our thinking. We buy a machine, you and I. We are, as I have suggested, very careful about that machine. In the first place we do not buy the machine unless we understand it. There is not one of us who would think of putting an apparatus into our office or shop that we did not understand. That means that we have given attention to the laws of that machine. We know what it can do. We should consider ourselves very, very absurd if we put into our factory any apparatus about which we could say that we had not studied its laws, and did not know how it operated, what its capacity of output might be, to what extent it would bear overstrain. . . . How many of us apply the same kind of thinking to the man or the woman we take into our shop, so infinitely more complex a machine than the loom or the shaper or the planer or the paper machine,—an infinitely more complex thing with all sorts of qualities to which most of us pay no attention. In fact, there is a word we use in that connection which by its very use shows the limitation of our thought. We say we employ so many 'hands.' The very use of the word shows that we do not appreciate the situation. We are not employing 'hands'; we are employing brains and hearts and dispositions, and all sorts of elements that make for personality—we are employing them all."
>
> —W. C. Redfield,
> "The Employment Problem in Industry"[1]

SELECTION AS A FACTOR IN INDIVIDUAL ADJUSTMENT

Fitting the worker to the job represents the first and perhaps the most important step in promoting individual efficiency and adjustment in industry.[2] The effect upon the individual of misplacement in work

[1] *Ann., Amer. Acad. Pol. Soc. Sci.*, 65 (1916), pp. 10–11.

[2] The phrase "fitting the worker to the job," as well as the term "selection" are used

cannot be over-emphasized. Excessive fatigue, excessive irritation, a complete loss of emotional balance may result from an attempt on the part of the worker to continue on a job for which he is not adapted. These effects are displayed not only in the factory—in production, in contacts with his fellow-workers and supervisors—but they may be carried into the home. When carried into the home, they may result in conflict between husband and wife, and in misunderstanding between father and children. The worker on the wrong job suffers not only from difficulties in social adjustment; he suffers from reduced earnings; he suffers from the probability of increased accidents and from many other similarly direct handicaps leading to the creation of a vicious circle of "misfortunes" from which he cannot extricate himself. The individual loses his job; he is crushed by the wheels of social life. Discouraged and embittered, he becomes a burden and a danger to the social body which, in the long run, pays a heavy penalty for the failure to settle systematically the fundamental problem of vocational placement.[3]

ECONOMIC FACTORS IN SELECTION

The cost of maladjustment in industry falls not only upon the individual but is reflected directly on the balance sheets of the individual industrial organization. Such costs too are of interest to society at large, inasmuch as wastefulness in production, whether it be in the use of material or of human resources, ultimately expresses itself in increased living costs and lowered standards of living.[4] In the transportation industry alone the waste in cost of accidents which can be avoided by the selection of competent operators amounts to millions. The street railway company of Paris reports an annual saving of over 1,300,000

in a broad sense to include both the *selection of new employees* and the selection of workers within the organization for *transfer* and *promotion*. The treatment of material in Section II of this text is oriented from the viewpoint that "scientific employment includes not only the selection of new employees, but also the keeping of every position in the organization permanently filled with the right kind of man or woman." (R. A. Feiss, "Personal Relationship as a Basis of Scientific Management," *Ann., Amer. Acad. Pol. Soc. Sci.*, 65 (1916), p. 130.) Transfer and promotion of workers already employed in the organization are as important in fitting the workers to jobs as hiring new workers. These aspects of placement have perhaps received less consideration than that of initial hiring, but it must be realized that the adequate selection of new workers must be supplemented by a systematized plan of holding and helping those who have been selected and of providing advancement for them. Provision for transfer becomes particularly important in times of economic depression, when it is necessary to shift personnel within the organization as a means of retaining employees with long years of service. The rapid replacement of men by machines also makes necessary an emphasis upon transfer and promotion as aids in promoting individual adjustment and efficiency in industry, and as a means of ensuring the stability of the plant and of the entire social body. (For a discussion of the concept of placement see C. S. Yoakum, "Psychology of Placement," in *Psychological Foundations of Management*, (Edited by H. D. Metcalf), Chicago, 1927, pp. 93–114.)

[3] H. Münsterberg, *Psychology and Industrial Efficiency*, New York, 1913, pp. 35–36.

[4] A. W. Kornhauser and F. A. Kingsbury, *Psychological Tests in Business*, Chicago, 1924, p. 172.

francs through an application of psychological techniques in the selection of accident-free motor-vehicle operators.[5] In the electric utility industry the actual cost of a single operating error on the part of an electrical substation operator may amount to as much as $80,000.[6] Numerous other examples in the form of cost of spoiled work, lost production time, compensation payments for accidents, could be cited in illustration of industrial costs which can be reduced by an organization of industry on the principle of every man in the best possible place.

THE EXTENT AND COST OF LABOR TURNOVER

A major item of unnecessary expense growing out of unsatisfactory selection or placement is the cost of *labor turnover*. A committee of the American Management Association has defined labor turnover as the *extent of shift and replacement of labor occurring in the maintenance of the working force*. In general, it is expressed as the ratio of yearly or monthly separations to the average number of full time workers for that period. There are enormous variations in the extent of labor turnover. At the moment of writing (1932) the monthly labor turnover among electrical substation operators employed by one utility (Philadelphia Electric Co.) is less than 1 per cent. Turnover among taxicab drivers employed by a large corporation in a nearby city is close to 10 per cent per *week*—500 per cent per *year*. In both cases there has been relatively little change in the percentage since the end of 1929, in spite of the marked change in the condition of the labor market.[7] A study, by Berridge,[8] of statistics furnished over a period of 10 years (1919–1929) by 350 companies employing an average force of 600,000, shows an average annual turnover of 48 per cent for the last 5 years of this period. Voluntary "quits" constitute 62.5 per cent of all turnover. Discharges and layoff constitute about 12.5 per cent of the total, the remainder representing increases in force and turnover from other causes.

The seriousness of high labor turnover results partly from its high cost to industry and to society. The cost of hiring and "breaking in"

[5] J. M. Lahy, *La selection psychophysiologique des travailleurs*, Paris, 1927, p. 213.

[6] M. S. Viteles, "The Human Factor in Substation Operation," *Pers. Jour.*, 8 (1929), pp. 81–113.

[7] The Mayor's Commission on Taxicabs gives 460 per cent as the annual turnover of one big fleet of taxicabs for the first 3 months of 1930, and describe this as typical of fleet operation in New York City. The company referred to in its report had an average force of 3,924 drivers for the 3 month period. To maintain the force it was necessary to hire 5,310 new drivers. In other words, to maintain an average force of 3,924, it would be necessary for the fleet to hire approximately 18,000 new drivers per year. (*The Taxicab Industry in New York City*, Reprint of the Mayor's Commission on Taxicabs, New York, 1930. See *Taxi Weekly*, October 6, 1930, p. 3.)

[8] W. A. Berridge, "Measuring Labor Turnover," *Pers. J.*, 8 (1929), pp. 197–206.

a new employee has been variously estimated at from $30.00 to $300.00, depending upon the kind of work, the character of training, the cost of spoiled work, etc. A recent report gives the following as the figures supplied by one employment manager for the cost of hiring and training: [9]

(1) Inexperienced workers who have had no previous experience $239.00
(2) Semi-skilled workers with previous experience, but no knowledge of the job to which they are assigned 190.00
(3) Operators skilled on operations for which they have been hired; employees who are rehired; workers transferred from other factories 24.00

Among detailed investigations of the cost of turnover is an early study by Alexander,[10] who surveyed 12 plants, located in 6 states, employing skilled and unskilled operators of both sexes in the manufacture of steam engines, electrical apparatus, fine tools, etc. A study of the cost of hiring these employees reveals the distribution of expense items for various types of employees as shown in Table 12.

In January, 1912, 37,274 employees were on the payrolls of the plants included in the study. During this year there was an increase of 6,697, bringing the total number employed at the close of the year to 43,971. During the same year 42,571 people had been hired. In other words, about 6⅓ as many people had to be hired as were required to meet the needs of the plants for new employees. By assuming that a certain percentage of replacement is due to such unavoidable causes as sickness, death, normal fluctuation of production, and allowing 80 per cent as a readily attainable efficiency of an employment department, Alexander reaches the conclusion that 22,031 people were employed above the apparently necessary withdrawals and replacements in these plants. When this figure is multiplied by the average cost for hiring the employees in various types of work, it appears that the unnecessary employment of 22,031 workers within one year in 12 factories involved an economic waste of $831,030.00, without allowing for increased overhead resulting from equipment which remains unused while the job is being filled.

According to Fisher and Hanna [11] it is estimated that from 20 to 25 million workers change jobs annually. Assuming that the average "breaking in" cost per worker is $45.00, the country is paying $900,000,000.00 each year for re-orienting workers who leave their jobs.

THE FUNCTION OF THE EMPLOYMENT DEPARTMENT IN REDUCING LABOR TURNOVER

Turnover results from a variety of causes. It naturally varies with jobs, wages, section of the country, season of the year, economic conditions, etc., but *dissatisfaction of the worker or employer—resulting from the unfitness of the worker for the job*—is unquestionably a major cause. In addition, the placement of the unemployed worker, regardless of the cause of separation, involves a determination of fitness for particular kinds of work. Economic waste resulting from turnover can be largely avoided through the initial placement on each job of individuals competent to perform the operations of that job.

TABLE 12

Cost of Labor Turnover

	NEW EMPLOYEES						RE-HIRED EMPLOYEES
TYPE OF WORK	HIRING	INSTRUCTION	WEAR AND TEAR	REDUCED PRODUCTION	SPOILED WORK	TOTAL	TOTAL
Highly skilled	$0.50	$ 7.50	$10.00	$20.00	$10.00	$48.00	$10.00
Skilled	.50	15.00	10.00	18.00	15.00	58.50	20.00
Semi-skilled	.50	20.00	10.00	33.00	10.00	73.50	35.00
Unskilled	.50	2.00	1.00	5.00	....	8.50	5.00
Clerical	.50	7.50	1.00	20.00	....	29.00	10.00

(After Alexander)

The elimination of such waste is one of the chief reasons for the existence of the Personnel Department, to which industry has assigned the specific function of "finding the right worker for the right job." The procedures employed by such departments in achieving this objective vary widely both in nature and validity. At one extreme is the amusing example of the haphazard method of selecting workers graphically described by Link. "One large manufacturing concern," he writes, "has appointed as monarch of the 'hiring-on-window' a man who had the misfortune to lose a leg in the company's employ. As a consequence of this loss he was given his present life job which he performs to the queen's taste. He was induced to describe his methods and they were something as follows. 'On Monday I turns down all the men with white collars, on Tuesdays all with blue eyes, Wednesday all with black eyes. Redheaded men I never hires, and there do be days when I have a grouch and hires every tenth man.' "[12] This is perhaps an exaggeration, but it illustrates a point of view which still persists in many industrial plants in spite of recent advances in the field of personnel administration. At the other extreme is the organization with a well established, centralized personnel department that makes use of detailed job specifications, application blanks, prolonged interviews,

[12] H. Link, *Employment Psychology,* 1919, New York, pp. 13–14.

psychological tests, and other available scientific techniques in selection, transfer, and promotion.

Between these two extremes is a vast confusion of viewpoints and procedures for selection. Italians are refused employment by one taxicab corporation because of their susceptibility to accident, while its neighbor, with offices not more than a mile away, gladly hires Italians and refuses employment to the Irish for the same reason.[13] The officers of neither would permit a minor change of an inch or two in the diameter of the steering wheel without investigating its possible effects upon operation, but they blithely adopt major personnel policies without thought of their experimental justification. "Snap judgments," "hunches," "intuitive judgment of men," and "first impressions" represent the tools of employment managers, when they are not depending upon the equally unreliable, but perhaps outwardly more impressive criteria of shape of head, protuberance of cheek bones, color of hair, and texture of skin. Münsterberg[14] at one time complained that employment managers seem particularly susceptible to pseudo-scientific theories, on the basis of which they become convinced that they are selecting men with special skill, knowing for each in which department he will be most successful. Münsterberg's criticism is perhaps harsh, and the readiness with which such theories are accepted is perhaps merely an indication of the need which is felt for more exact methods of selection than the employment manager ordinarily has at his disposal. At the same time, the uncritical acceptance of such theories results in gross injustice both to the individual worker and to the industrial organization.

SCIENTIFIC METHOD IN VOCATIONAL SELECTION

The chief purpose of the application of psychology in selection is to develop experimentally validated methods with known predictive value or forecasting efficiency in fitting workers to jobs. The first step in the development of such techniques must take the form of an evaluation of traditional methods in selection. It is quite possible, for example, that Italians or Irish *are* actually more susceptible to accidents than other groups. The interviewer may perhaps become as skilled in the recognition, at sight, of more common behavior tendencies as the physician is in the diagnosis of certain diseases. The application blank, under certain conditions, may be more valuable than the psychological test. The experimental examination of these, and other tools of the employment manager, represents a necessary step in the development of scientific selection methods. The result of such experimental studies will be briefly described in Chapter X.

The evaluation of traditional methods is followed by the develop-

[13] See Chapter XVIII, pages 354–56.

[14] H. Münsterberg, *op. cit.*, pp. 13–14.

ment of other techniques to supplant or supplement available procedures which are inadequate in fitting workers to jobs. Such techniques, whether they be elaborations of traditional methods or entirely new procedures, are concerned primarily with (1) ***measurement of individual differences,*** and (2) ***prediction of vocational success or failure,*** a statement of the chances for success or failure on the part of an individual who has not had an opportunity to practice the operations of the job under the conditions as they exist. A significant feature of scientific vocational placement is that it represents "an effort to replace uncertainty, chance and guess by relative certainty and predetermined results." [15] It is an effort to stack the odds against failure on the part of the worker, to increase the chances of success and adjustment by an exact determination, prior to placement, of his fitness for the job.

PROBLEMS IN THE MEASUREMENT OF VOCATIONAL FITNESS

The Traits to be Measured

Fitness for work refers to that combination of traits which will enable the individual to adjust himself satisfactorily to the working situation. In general, the object of scientific selection is to place on each job a worker who can maintain a given output with the least possible expenditure of energy [16] and who will be least susceptible to maladjustment.[17]

Fitness for work is determined first of all by the ***physical characteristic*** of the individual, that is, general soundness of body and limbs, height, weight, etc. These will not be discussed in detail in this volume. In addition, as will appear more clearly in Chapter X, certain ***personal characteristics*** such as age, marital status, number of children, place of birth, etc., apparently have a determining influence in adjustment to certain kinds of work. The ***major factors*** in individual fitness for specific jobs are (1) ***proficiency,*** (2) ***competency,*** (3) ***temperament and character,*** and (4) ***interest.***

[15] H. S. Person, "Major Problems of Management," in *Scientific Foundations of Business Administration* (Edited by H. C. Metcalf), Baltimore, 1926, p. 247.

[16] B. Muscio, *Lectures on Industrial Psychology,* London, 1920, p. 104.

[17] See Chapter XXVI.

The problems involved in measuring fitness for work cannot, of course, be completely separated from those of maintaining fitness at work, considered in *Section III*. In addition to determining fitness, conditions of work must be so arranged that they will require the least possible expenditure of energy, so that fitness can be most easily maintained. As Scott, Clothier and Mathewson have pointed out, "personnel management is not merely a problem of discovering the right man for the right place,—the somewhat obsolete conception of square pegs for square holes. . . . Industry cannot merely bring two rigid, inelastic units together which are so shaped that they will fit, for the worker and his job cannot be separated into units. Both are plastic and changing in themselves, the job exercising an influence on the worker and likewise the worker influencing the work. . . . The task of management is to make every worker-in-his-work unit as effective as possible." (W. D. Scott, R. C. Clothier and S. B. Mathewson, *Personnel Management,* Rev. Ed., New York, 1931, pp. 8–18). Procedures for maintaining optimal effectiveness, broadly defined, are discussed in Section III.

PROFICIENCY AS A FACTOR IN VOCATIONAL SELECTION

The selection of workers for certain jobs is determined in part by the attained proficiency of the individual in performing the duties of that job. So, for example, the selection of a prospective stenographer is partly dependent upon whether she already has acquired the desired speed and accuracy in taking and transcribing dictation. This also applies to many other jobs in the field of office work, such as comptometer operating, typing, Hollerith machine operating, etc. It is unusual, in the field of taxicab operation, to hire a driver unless he already possesses a high degree of *skill* [18] in the operation of a motor vehicle. Although some firms hire and train apprentice machinists and tool makers, others demand only proficient workers who, through suitable training and experience, have acquired the necessary skills for performing satisfactorily the work required of them. The determination of proficiency in many varied activities represents, therefore, a basic problem in fitting workers to jobs.

THE PLACE OF COMPETENCY IN VOCATIONAL SELECTION

Competency, in so far as the work situation is concerned, may be defined as the *potentiality* of an individual for learning and becoming proficient in some particular job. It represents the individual's capacity to acquire the knowledge and skill necessary for successful achievement on the job.[19]

Many terms have been used in referring to this potentiality for vocational success or failure. *Capacity, ability, trait, aptitude,* and even *intelligence* and *general intelligence* have been used interchangeably with reference to this aspect of individual make-up. In this discussion of vocational fitness the term competency will generally be employed in referring to the *trainability* and *perfectability* of the individual in particular kinds of activities—in activities as widely varied as the operation of a punch press and the leadership of an industrial organization. Employed in this sense, competency may be conceived as a complex pattern of abilities, either *general* or *special.* These abilities may be viewed as combined in a *summative* fashion, if one adopts an analytic

[18] The author follows Pear in defining *skill* as *the integration of well adjusted performances adapted under varying situations to the attainment of desired results. It is the congeries of habits developed and integrated through practice into a unified pattern of behavior suitable for meeting the needs of the task.* Habit represents efficiency in the specific operation; *ability,* a level of functioning developed largely by practice; and *capacity,* inherent mechanism. *Skill* is an integration of well-adjusted performance—a pattern of performance characterized by complexity, integration, and adaptability to changing situations, the aptitude for which is based upon well co-ordinated reflexes, instincts suitable to the task, adaptive habits, and the power, or maybe powers, of patterning. (See T. H. Pear, *Fitness for Work,* London, 1928, p. 187; "The Nature of Skill," *J. Nat. Inst. Ind. Psych.,* 4 (1928), pp. 193–202; "Skill," *J. Pers. Res.,* 5 (1927), pp. 478–389.)

[19] C. L. Hull, *Aptitude Testing,* Yonkers, N. Y., 1928, p. 50.

viewpoint in the treatment of competency, or in a ***configurative*** manner, if one emphasizes the more recently developed ***gestalt*** viewpoint in psychology.[20] In general, the term ability is used in the same sense as that in which Pear employs the word "capacity"—as referring to the inherent mechanisms of mental activity and of human response.

However, in spite of the author's preference for this terminology, there will be no attempt to cut through the Gordian knot of disagreement in the use of concepts in the presentation of data in his text. In general, in discussing the work of particular investigators, the author will use terms employed by the investigator in the distinctive sense in which he himself uses them. The attempt to translate these various approaches into a common terminology can only result, in the opinion of the author, in a distortion of the viewpoints of individual investigators.

The Significance of General Intelligence

Among fundamental problems in the measurement of vocational competency is the significance of general intelligence in determining fitness for the job. The rapid rise of industrial psychology in the United States after the war is associated with the extensive use of the army and other general intelligence tests in the selection of workers. This movement received support from the study of intelligence levels of men employed in various occupations. The results of one such study are presented in Figure 15, which gives the *median* score and the *range of the middle 50 per cent* of scores on the Army tests of a number of occupational groups, including a total of over 18,000 workers.[21]

The chart shows, for example, that the median score of barber is C — ; that of general auto repair man C; and that both of these are considerably below the median score of accountants, B, and of engineering officers, A.[22] The range of the middle 50 per cent of scores of barbers is from C to D, whereas that of accountants is from C + to A. In other words, less than 25 per cent of accountants have a general intelligence level as low as that which characterizes 75 per cent of the barbers. A further analysis shows that although 90 per cent of the chaplains, 95.9 per cent of the engineering officers, and 77.5 per cent of the medical officers are found at the general intelligence levels indicated by the

[20] M. S. Viteles, "Die 'Gestalt' Betrachtungsweise in der angewandten Psychologie," *Z. ang. Psych.*, 35 (1930), pp. 525–31.

[21] See also D. Fryer, "Occupational Intelligence Levels," *Sch. and Soc.*, 16 (1922), pp 273 ff.

[22]

Intelligence Grade	*Definition*	*Score* *Army Alpha*	*Army Beta*
A	Very superior	135–212	100–118
B	Superior	105–134	90– 99
C +	High Average	75–104	80– 89
C	Average	45– 74	65– 79
C —	Low Average	25– 44	45– 64
D	Inferior	15– 24	20– 24
D —	Very Inferior	0– 14	0– 19

ratings A and B, only 9.5 per cent of carpenters, 9.2 per cent of painters, 6.9 per cent of the barbers attain those levels of intelligence.[23]

Such figures have been accepted as an indication that there exists a

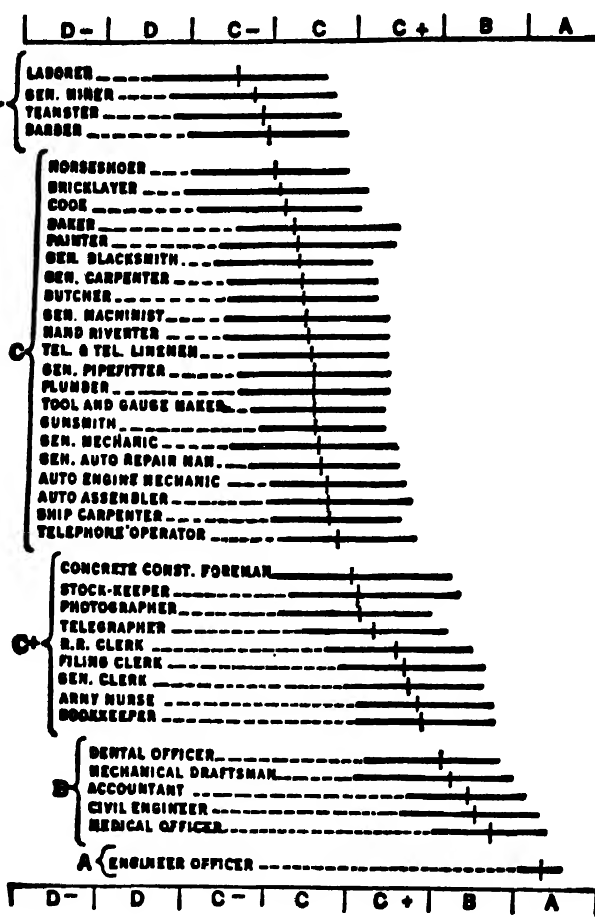


FIGURE 15. *Occupational Intelligence Ratings*

Letter grades on horizontal scale. Length of bar for each occupation is mid-range of 50 per cent; median point is shown by a cross line

(*From Memoirs of National Academy of Sciences, Vol. XV*)

selective process which tends to prevent men of low intelligence from satisfactorily filling certain jobs, which favors men of high intelligence for such jobs, and vice versa.[24] A study by Bills [25] of 133 clerical

workers, in which the correlation between intelligence and the difficulty of the work performed was found to be + 0.22, represents evidence of another kind pointing to the existence of such a tendency. For the group remaining in employment after a lapse of 2½ years, the correlation was + 0.41, indicating that those scoring low in intelligence tended to leave the jobs which were too difficult and that those high in intelligence tended to leave jobs which were too easy. A similar relationship has been observed by the author in a study of cashiers in a department store.[26] Such findings suggest that it is important to determine the minimum intelligence requirement for each occupation and to employ some measure of general intelligence in finding out whether the individual meets this requirement. In addition, variations in efficiency and satisfaction paralleling changes in test scores suggest the possibility of making use of critical scores in gauging the probabilities for an individual at a given intelligence level to be successful in a given job.

Studies of the relationship between general intelligence and success in specific jobs have lent further support to the procedure of gauging general intelligence in determining vocational fitness. Bills,[27] for example, has found that 8 secretaries rated as "good" make an average score of 144 on a general intelligence test. Of 15 stenographers, those rated as "good" make an average score of 110; those rated as "getting by," 65; and those "failing," 63. Scudder[28] has employed an intelligence test in examining 262 veterans taking a course in bookkeeping and accounting. The median score of those who finished the course was found to be 142; for those who failed to complete, the median score was 112. A follow-up approximately 3 years after the completion of the course showed that of the 103 remaining in employment at this time, the average monthly increase in wages for the upper ten (in general intelligence score) amounted to $145.00, for the middle ten, $73.00, and for the lowest ten, $41.00. Kornhauser[29] has given a general intelligence test to several small groups of employees and found close agreement between test scores and the estimated ability of workers by their supervisors. In the case of one group there appared an almost consistent decrease in the per cent leaving the company with increasing test scores, although in another the same relationship between general intelligence and turnover existed which has been reported by Bills and by Viteles. Filer and O'Rourke have reported the satisfactory use of general intelligence (general adaptability) tests as

part of the examination for office positions given by the United States Civil Service Commission.[80] From a survey of tests for office occupations Kornhauser and Kingsbury have concluded that "in the case of tests for clerical work, results have consistently pointed to the value of general intelligence tests and adaptations of these in predicting success." [81]

Somewhat similar results have been reported in the case of a number of non-office occupations. Wembridge [82] found a correlation of + 0.51 between a general intelligence test, modelled upon Army Alpha and Beta, and proficiency of machine operators in a clothing plant. From a study of over 600 boys receiving trade training in state schools Cowdery [83] has concluded that general intelligence influences trade success. The degree of influence differs in the various trades. In general, the number of cases in each group is small and the coefficients of correlation low. Terman [84] has suggested that no applicant with an I.Q. below 80 be accepted for the positions of policeman and fireman, although there is no clear indication of the relationship between success on these jobs and the minimum or higher I.Q. Alderton [85] recommends a minimum I.Q. of 85 in selecting junior employees for retail stores.

The Limitations of General Intelligence as a Factor in Vocational Fitness

In spite of the results cited above, there seems reason to believe that general intelligence exercises a very limited influence in determining occupational success. In the first place, Figure 15 shows that the median intelligence and the range of the middle 50 per cent of general intelligence test scores on such varying jobs as bricklayer, cook, baker, general machinist, shop carpenter, and of workers in a number of other trades are approximately alike. If vocational competency were to any large extent determined by general intelligence, it could be predicted that everybody who has a rating of C on the Army general test would make an equally good bricklayer, cook, baker, or general machinist. It is a matter of common experience that many bricklayers cannot be trusted to prepare a satisfactory meal, even after much training, and that many first class chefs could be taught bricklaying

[80] H. A. Filer and L. J. O'Rourke, "Progress in Civil Service Tests," *J. Pers. Res.*, 1 (1923), pp. 484–520. See also *Annual Reports* by L. J. O'Rourke, Director of Research, United States Civil Service Commission, 1923 to 1931, inclusive.

[81] A. W. Kornhauser and F. A. Kingsbury, *Psychological Tests in Business*, Chicago, 1924, p. 99.

[82] H. A. Wembridge, "Experiment and Statistics in the Selection of Employees," *Quat. Pub. Amer. Stat. Assoc.*, 18 (1923), pp. 600–606.

[83] K. M. Cowdery, "Measures of General Intelligence as Indices of Success in Trade Learning," *J. App. Psych.*, 6 (1922), pp. 311–329.

[84] M. Terman, "A Trial of Mental and Pedagogical Tests in a Civil Service Examination for Policemen and Firemen," *J. App. Psych.*, 1 (1917), pp. 17–29.

[85] C. C. Alderton, "Store and School: Factors in the Success of Department Store Workers," *Pers. J.*, 9 (1930), p. 321.

for many years and would never succeed in aligning properly a row of bricks. The figure also shows an enormous amount of overlapping in the general intelligence test scores of diverse occupations. Although the median general intelligence level of engineers is A, and that of pipe fitters C, there are pipe fitters who have A ratings in general intelligence and who, as far as is known, are efficient and well adjusted in their jobs. There are dentists with ratings below C, which is the median for painters. It is possible that such dentists are not successful, but there is no *direct* evidence to this effect in available data. It is likely that the probability for success in dentistry of an individual with an intelligence level of C is lower than that of an individual with an intelligence level of A, but on the other hand, this is no reason for believing that the individual with the intelligence rating of A will be less well adjusted in the occupation of painter than the individual with the intelligence rating of C.

These general considerations are supported by available evidence on the relationship between general intelligence test scores and success on a variety of jobs. Otis [36] reports no agreement between intelligence test scores and production records of 400 employees in a silk mill. Thurstone [37] has found general intelligence tests of no value in diagnosing ability to learn telegraphy. On the basis of careful study of a variety of factory jobs, including inspecting, gauging, assembling, tool making, etc., Link [38] has reached the conclusion that the standard general intelligence test has no significance in predicting success in these types of work. The same conclusion has been reached by Viteles [39] in the case of motormen, by Pond [40] in the case of toolmaking apprentices, by Taylor [41] in the case of compositors' apprentices, etc. A very striking confirmation of the limited influence of general intelligence upon success is found in a recent study by Unger and Burr,[42] involving a determination of the proportion of successes and failures of girls at a variety of mental age levels in packing jobs, miscellaneous light factory work, assembly work, garment machine operating, filing, clerical work, etc. The results, illustrated in Table 13, showing the proportion of successes and failures at each mental age level for

[36] A. S. Otis, "The Selection of Millworkers by Mental Tests," *J. App. Psych.*, 4 (1920), pp. 339–41.

[37] L. L. Thurstone, "Mental Tests for Prospective Telegraphists," *J. App. Psych.*, 3 (1919), pp. 110–117.

[38] H. C. Link, "Psychological Tests in Industry," *Ann. Amer. Acad. Pol. Soc. Sci.*, 110 (1923), pp. 41–43.

[39] M. S. Viteles, "Research in the Selection of Motormen," *J. Pers. Res.*, 4 (1925), pp. 193–195.

[40] M. Pond, "Selective Placement of Metal Workers," *J. Pers. Res.*, 5 (1927), pp. 345–68; 405–17; 452–66.

[41] A. D. Taylor, "Intelligence of Young Printers," *Pers. J.*, 8 (1929), pp. 29–35.

[42] E. W. Unger and E. T. Burr, *Minimum Mental Age Level of Achievement*, Albany, 1931, pp. 108.

413 packing jobs, are characteristic of the findings of this study. In the case of executives, Bingham and Davis [48] have shown that for 102 individuals scoring above the Army median score on a general intelligence test of the Army type the correlation between general intelligence score and business score is — 0.10, and have concluded that "superiority in intelligence, above a certain minimum, contributes relatively less to business success than does superiority in several non-intellectual traits of personality."

TABLE 13

The proportion of successes and failures at each mental age level for 413 packing jobs

MENTAL AGE	TOTAL NUMBER CASES AT M.A.	NUMBER SUCCESSES AT M.A.	PER CENT SUCCESSES AT M.A.	NUMBER FAILURES AT M.A.	PER CENT FAILURES AT M.A.
5– 5.11	1	1	100	..	..
6– 6.11	5	4	80	1	20
7– 7.11	13	13	100	..	..
8– 8.11	48	46	96	2	4
9– 9.11	67	65	97	2	3
10–10.11	82	78	95	4	5
11–11.11	58	57	98½	1	1½
12–12.11	53	52	98	1	2
13–13.11	42	42	100	..	..
14–14.11	20	19	95	1	5
15–15.11	9	9	100	..	..
16–16.11	11	11	100	..	..
17–17.11	3	3	100	..	..
18–18.11	1	1	100	..	..
Total	413	401	97	12	3

(After Unger and Burr)

Minimum General Intelligence Levels

Although there is growing agreement on the limited influence of general intelligence score in determining the success of groups in specific jobs, there is still a tendency to attach considerable importance to *minimum intelligence level* as a significant factor, although little has been done to establish valid minimum intelligence levels for individual jobs. Occupational groupings on the basis of I.Q. and Mental Age have

[48] W. V. Bingham and W. T. Davis, "Intelligence Test Scores and Business Success," *J. App. Psych.*, 8 (1924), pp. 1–22.

been prepared by Burt,[44] Fryer,[45] Awaji,[46] and others, but these are not helpful in the selection for particular jobs. In specific jobs for which minimum levels have been established, the level proves to be so low as to have little practical significance in the selection of workers

TABLE 14

Lowest mental age that will succeed at each type of work

MINIMUM MENTAL AGE LEVEL

5	6	7	8	9	10	11
Packing	Misc. light factory	Assembling Errand girl Examining Pasting	Cutting Folding Garment machine operating	Hand sewing Press operating Filing Stock girl	Clerical	Selling

(After Unger and Burr)

for industry.[47] This appears clearly in Unger and Burr's [48] study, which leads to the classification of minimum mental age levels shown in Table 14. Such results suggest that the minimum intelligence level is probably a significant factor in the placement of the border-line deficients and the feeble-minded in many jobs. However, the proportion of such deficients in the population is so small, and industry has so wide a possible choice from levels above the minimum that, as a practical matter, the minimum intelligence level would appear to have little direct bearing upon the selection of competent workers in the majority of jobs. There still seems reason to believe that in the case of jobs at the professional level, and in the case of certain office and technical jobs, intelligence level is a significant factor. For this reason, general intelligence may also be viewed as an important factor in promoting workers to advanced positions within the organization. In hiring new workers for the large proportion of jobs in industry, the concept of minimum intelligence level is of little significance.

The Nature of General Intelligence

The limitations of general intelligence measurement follow largely from the nature of general intelligence. Many attempts have been

[44] C. Burt, "The Principles of Vocational Guidance," *Brit. J. Psych.*, 14 (1923–24), pp. 336–352.
[45] D. Fryer, "Occupational Intelligence Standards," *Sch. and Soc.*, 1922, pp. 273 ff.
[46] Y. Awaji, "Intelligenzprüfung im Japanischen Heere," *Z. ang. Psych.*, 30 (1928), pp. 81–118.
[47] E. Burr, "Minimum Intelligence Levels of Accomplishment in Industry," *J. Pers. Res.*, 3 (1924), 207–12.
[48] E. W. Unger and E. T. Burr, *op. cit.*, p. 93.

made to define general intelligence. A survey of views expressed by different authors leaves the reader with the impression of a bewildering confusion and incompatibility of thought. Hardly any two investigators have agreed on a definition of this term, except when so vaguely stated as to be almost completely devoid of significance.[49] Among the definitions which have been suggested are "capacity to acquire capacity," "the ability to carry on abstract thinking," "a common average of many different factors," "the capacity to inhibit instinctive behavior in an unfinished stage of its formation," and "to modify it at that stage by means of an imaginal stimulus which is relatively remote from that which is immediately and perceptually present." [50] So diverse are these opinions that many engaged in measurement of general intelligence have reached the conclusion that the wisest procedure is to apply the tests which have been devised without attempting to describe what the tests measure. The criterion in this approach is the consistency in the value of results obtained by applying the measure of general intelligence without regard for its nature. The precedent for using measures in this way is found in the prevalent use and measurement of electric energy without a knowledge of the essential nature of electricity.[51]

In spite of this diversity of opinion, the fact that general intelligence results have been more valuable in producing success in academic work than in any other field is rapidly leading to an acceptance of the viewpoint that this type of test measures essentially the capacity to learn academic school subjects and that general intelligence, in so far as it is measured by standard tests, *refers to the resources of the individual which determine the degree of excellence in intellectual attainment.* As Paterson and his associates have pointed out, this is the generally accepted definition of general intelligence evolved in the course of attempts to measure it. "Intelligence characterizes individuals who succeed in intellectual activities—that is, individuals who make good school progress, who master certain academic subjects, who achieve success in the arts or in the learned professions, or, in general, who are skilled in complex situations requiring the manipulation of symbols." [52]

This concept of general intelligence naturally limits the value of its measurement in vocational selection, inasmuch as there exists a wide range of occupations in which intellectual attainment is a relatively unimportant and even negligible factor in successful achievement. It is true that the abilities required for academic attainment or school success are likewise required in certain jobs, as in many of the other

[49] M. McFarlane, "A Study of Practical Ability," *Brit. J. Psych.*, Monog. Suppl., 8 (1925), p. 4.

[50] "Symposium on Intelligence and its Measurement," *J. Ed. Psych.*, 12 (1921), pp. 123–147, 195–216, 271–275; J. Peterson, *Early Conceptions and Tests of Intelligence,* Yonkers, N. Y., 1925, pp. 320. (See particularly Chapter 13.)

[51] C. H. Griffitts, *op. cit.*, p. 291.

[52] D. G. Paterson, R. M. Elliott, L. D. Anderson, H. A. Toops, E. Heidbreder, *Minnesota Mechanical Ability Tests,* Minneapolis, 1930, p. 6.

varied activities of daily existence. To this extent general intelligence must be considered in determining vocational fitness. In others, scholastic ability plays no part in achievement. The prediction of success in these must depend upon the measurement of abilities other than those tapped by the ordinary general intelligence examination. The problem becomes that of discovering the combination of specialized abilities which characterizes each occupation and of providing means of observing or measuring these as a way of determining fitness for work.

The Significance of Other Abilities

The need for measuring such other abilities receives further support from experimental research on the nature of general intelligence and of its relation to other abilities. One prevailing concept of general intelligence is that of Spearman,[53] who has looked upon it as a basic mental function appearing in many diverse mental processes. Each activity, according to this investigator, involves the functioning of two factors —a factor *specific* to each activity and a *general* factor "g" which appears again and again in many different intellectual activities. The general factor, or "g," is described as the most important influence in determining the level of performance in such diverse activities as progress in school and in the simple act of discriminating nearly identical tones.[54] It is responsible for the quantitative aspect of the mental process, while the specific factor accounts for its qualitative aspect, although the relative influence of the two, according to Spearman, varies with respect to the character of the activity.[55] This viewpoint, carried to its logical conclusion, makes "general intelligence" the predominating factor in the majority of activities and establishes a theoretical basis for its measurement as a fundamental approach in determining vocational fitness. This implication of Spearman's theories is expressed in a recent article by Earle, who points out that if "g" is taken to be roughly equivalent to the "general intelligence" which is universally presupposed in successful work "it often occurs . . . that a person with a high endowment of intelligence, who lacks a high degree of the specific ability needed for a particular job, will succeed in the task equally with one who possesses only low intelligence but greater specific ability." [56]

The antithesis of Spearman's position on the *nature* of general intelligence is to be found in the viewpoint of Thorndike,[57] who in 1909 published results of an investigation (carried out in association with

[53] C. E. Spearman, "General Intelligence Objectively Determined and Measured," *Amer. J. Psych.*, 15 (1904), pp. 201–293; "The Theory of Two Factors," *Psych. Rev.*, 21 (1914), pp. 101–115.

[54] *Ibid.*, p. 274.

[55] C. E. Spearman, *Nature of Intelligence*, London, 1923, pp. 65–66.

[56] F. M. Earle, "Vocational Testing in Relation to Professor Spearman's Theories," *J. Nat'l Inst. Ind. Psych.*, 3 (1927), p. 416.

[57] E. L. Thorndike, W. Lay, P. R. Dean, "Relation of Accuracy in Sensory Discrimination to General Intelligence," *Amer. J. Psych.*, 20 (1909), pp. 364–369.

Lay and Dean) that appeared to be in contradiction with the conclusion reached by Spearman concerning the significance of a common or general factor. These results led him to "reject Spearman's doctrine of the presence of a general factor which permeates all mental activities in favor of the view that there is but slight connection between different forms of mental ability." [58] In so far as the nature of general intelligence is concerned Thorndike draws the conclusions that "the present results support the contrary hypothesis that the efficiency of a man's equipment for the specifically human task of managing ideas is only loosely correlated with the efficiency of the simpler sensori-motor apparatus which he possesses in common with other species," and that "in general there is evidence of a complex set of bonds between the psychological equivalent of what we call the formal side of thought and what we call its content, so that one is almost tempted to replace Spearman's statement by the equally extravagant one that there is nothing *whatever* common to all mental functions." [59]

Essentially, Thorndike's conclusion is that the general intelligence of the individual is determined by the diversity of specific abilities which enter into a given performance. In this sense *general* capacity or intelligence is the average of many different specific abilities. At the same time, Thorndike, in the earlier statements of his theory, showed virtual agreement with Spearman with respect to the importance of general intelligence in determining individual adjustment to the very many diverse activities of daily life. However, the level of performance is for Thorndike determined not by "some general power which resides in him," [60] but results from the fact that in human nature good traits tend to go together, so that the individual who rates high in one trait will tend to rate high in others, and therefore shows superiority in many diverse, unrelated activities.

These contradictory theories, diametrically opposed as originally stated, have undergone very pronounced modification in the hands of their originators and as a result of experimental investigation by Burt,[61] Thomson,[62] Kelley,[63] Hull,[64] and others. It is unnecessary, within the scope of this volume, to include a discussion of these experimental studies or a comparison of the detailed characteristics of each. Burt's results, for example, demonstrated that special abilities,

[58] M. McFarlane, "A Study of Practical Ability," *Brit. J. Psych.*, Monog. Suppl. 8 (1925), p. 6.

[59] E. L. Thorndike, W. Lay, P. R. Dean, *op. cit.*, pp. 367–368.

[60] E. L. Thorndike, "On the Organization of the Intellect," *Psych. Rev.*, 28 (1921), pp. 139–151.

[61] C. Burt, "Experimental Tests of General Intelligence," *Brit. J. Psych.* 3 (1909), pp. 94–177; *Mental and Scholastic Tests*, London, 1921, pp. 432.

[62] G. H. Thomson, "A Hierarchy Without a General Factor," *Brit. J. Psych.*, 8 (1916), pp. 271–281; "General versus Group Factors in Mental Activities," *Psych. Rev.*, 27 (1920), pp. 175–190.

[63] T. L. Kelley, *Crossroads in the Mind of Man*, 1928, pp. 238.

[64] C. L. Hull, *op. cit.*

instead of being absolutely specific or of a very narrow range, spread over a wide distribution of school subjects, so that they can be arranged in groups described as *arithmetical, manual, linguistic,* and *composition,* respectively.[65] Instead of regarding intelligence as the effect of a general factor and an infinite number of independent specific factors, Burt regards it as a highly organized system within which may be distinguished the common factor referred to, and many other factors of greater or less influence, some of which are knitted together in complex fashion. Thus he says: "We are led to infer that all the functions of the human mind, the simplest and the most complicated alike, are probably processes within a single system. A process typical of higher psycho-physical 'levels' may be connected with a process typical of lower psycho-physical levels far less intimately than either is with a process of intermediate 'levels.' Yet this relatively small correlation is not a disproof but a consequence of their inclusive organization within a single integrated system of psychical dispositions or of neural arcs." [66]

Burt's emphasis is on the overlapping of factor from group to group. The significance of group factors appears more specifically in the work of Thomson, who has severely criticized Spearman's statistical procedures and interpretation of statistical findings, and whose results generally support the theory that any given test performance may be regarded as a sample of the various abilities at an individual's command, and that there may be *quasi-general* or *group* factors in addition to a general factor and specific factors, that is, factors intermediate in generality between the two.

The more recent evolution of these distinct theories of general intelligence has brought apparently antagonistic points of view together in such a way as to give the impression that at present they have a good deal of ground in common. Spearman now attaches a great deal more importance to the specific factors than appeared in his early work and he admits that they may extend over a number of activities.[67] Thorndike no longer emphasizes the independence of traits, but insists rather upon their complex character and recognizes that certain traits may extend over such wide fields as to be almost general in character.[68] The general emphasis now appears to be upon distinct levels of behavior and upon diverse patterns of activities made possible, in part, through the changing influence of *group* factors which determine success in each of a number of varied kinds of activities. So, for example, Thorndike has put forward a theory distinguishing among *three* types of intelligence with respect to the material upon which the most suc-

[65] C. Burt, *The Distribution and Relations of Educational Abilities,* London, 1917, pp. 93.

[66] *Ibid.*, p. 165, and M. McFarlane, *op. cit.*, p. 11.

[67] C. Spearman, *The Abilities of Man,* London, 1927, pp. 415.

[68] E. L. Thorndike, "Intelligence and its Uses," *Harper's Magazine,* 79 (1920), pp. 228–229. See also E. L. Thorndike and others, *The Measurement of Intelligence,* New York, 1926, pp. 616.

cessful responses are made. "A perfect description and measurement of intelligence would involve testing the man's ability to think in all possible lines. . . . For ordinary practical purposes, however, it suffices to examine for three 'intelligences,' which we may call *mechanical intelligence, social intelligence,* and *abstract intelligence.* By mechanical intelligence is meant ability to learn to understand and manage things and mechanisms. . . . By social intelligence is meant the ability . . . to act wisely in human relations. By abstract intelligence is meant the ability to understand and manage ideas and symbols. . . . Mechanical intelligence and social intelligence refer to thought and action directly concerned with actual things and persons in one's hands and before one's eyes. When the mind works with general facts *about* things and people . . . its action is referred to as abstract intelligence." [69]

Another illustration of a recent development emphasizing diversity rather than uniformity in mental ability and presenting a theoretical justification for an emphasis, in vocational selection, upon traits other than general intelligence, is found in the theory of unique traits proposed by a group of investigators at the University of Minnesota. This theory makes two basic assumptions: (1) *that the various degrees of success in all the important classes of human behavior correspond to compounds of relatively unitary traits, combined in various proportions,* and (2) *that these unitary traits can be discovered and measured objectively* and are probably not so numerous as to make impossible the task of measuring them all.[70] According to this theory the differences between occupational fitness can be expressed in terms of quantitative differences in a few traits. A trait may be judged unique (1) when it correlates positively with at least one criterion of human behavior, and (2) when it shows low correlation with all other unique traits.

As far as measuring fitness for work is concerned, this theory makes it necessary (1) to determine the unitary traits in human personality, (2) to devise adequate methods for measuring them, and (3) to determine the traits required for a given kind of activity and the amounts necessary for success. According to this theory, "the difference between a machine tender and a farm hand, for example, is a matter of differences in a few particulars such as physical strength, ability to resist monotony, scope of attention, mechanical aptitude, and intelligence. Similarly, these and other capacities may serve to distinguish the machine tender from the tool maker, the tool maker from the foreman, the foreman from the administrative officer. In the two occupations last named, executive ability and social aptitude, qualities

[69] E. L. Thorndike, "Intelligence and Its Uses," *op. cit.*, pp. 228–229.

[70] D. G. Paterson, R. M. Elliott, L. D. Anderson, H. A. Toops, E. Heidbreder, *op. cit.*, p. 14.

which have little importance in the other occupations on the list, are probably of dominant importance." [71]

Approaching the problem from a somewhat different angle, Hull has outlined a theory of aptitude testing which emphasizes the diversity of traits to be measured in the determination of vocational fitness. The basic concept of this theory is the existence of *group factors* or *determiners* of efficiency. "These determiners, or factors, unite in various combinations to produce the various aptitudes which an individual possesses. The same determiner in most cases will contribute to the success of numerous different activities. Some determiners, perhaps, may be constituents of no more than three or four activities, while others may contribute to the efficiency of several hundred. The former may be narrow-range group factors, approaching the Spearman specific factors; the latter would be wide-range group factors, approaching the Spearman general factor." [72] The problem, in any case, is to measure that combination of group factors which determine success in the particular activity or job under consideration.

The Significance of Competency—General Conclusion

This discussion of the theoretical problems in the measurement of human competency shows further the limitations of general intelligence testing in determining vocational fitness, and indicates why the most promising line of advance in vocational selection lies in the detailed study of more specialized traits or combinations of traits. The experimental results cited above, combined with these considerations of theory, warrant the conclusion that general intelligence tests have an extremely limited sphere of usefulness in the scientific placement of workers. They can be used, in the first place, to shut out the low grade feeble-minded and in the assignment of the higher grades to suitable jobs within the organization. They can be used in selecting executives, certain supervisory, technical, and office workers. For selection in the great mass of skilled and semi-skilled jobs, in many office and clerical jobs, the measurement of general intelligence can serve little purpose. The problem is that of determining and providing techniques for objectively measuring the combination of specialized traits which find an outlet in the activities of each of these jobs.

TEMPERAMENT AND CHARACTER IN VOCATIONAL FITNESS

Among the major factors in vocational fitness are *temperament* and *character*.[73] "It is only natural," writes Symonds, "that the first con-

[71] *Ibid.*, p. 14.

[72] C. L. Hull, *op. cit.*, p. 218.

[73] The consideration of temperament and character in vocational fitness, as that of competency, is complicated by a confusion of terminology. In the first place, there is

sideration in hiring a worker should be his ability to do the task at hand. But it has been discovered that conduct factors are also important in estimating a worker's value. He must not only be able to do the job, he must get along with people and also have certain qualities of regularity, thoroughness, willingness to stick to the job, and the like." [74] From the point of view of competency two applicants may be equally suited for the job of street-car motorman. Both may profit equally from training and develop identical proficiency in the safe operation of the street car. However, there will be marked difference between the two in accomplishment if one is susceptible to frequent variations in mood, if his feelings are easily hurt by remarks of patrons, if he generally dislikes people, is inclined to disregard punctuality, etc., while the other is generally "stolid," unmoved by the comments of others, easily adapts himself to a daily routine, etc.[75]

It is not only important that the cashier be "intelligent" and accurate, but that he be able to refrain from pocketing his employer's money when the opportunity or temptation is present. As a matter of fact, in many occupations, as Baumgarten has pointed out, although "character traits" may offer compensation for deficient intelligence, a high degree of intellectual competency never serves as a substitute for such qualities as trustworthiness and honesty.[76]

In the entire gamut of occupations, from unskilled work to the management of an industrial enterprise, it is important to know something about the individual's "character," his habits of work, "his way of reacting" in this or that situation, his "driving forces," in determining his

no agreement among psychologists with respect to the scope of such fundamental terms as *"personality," "temperament," "character,"* etc. In addition, there is a wide variety of descriptive words and phrases used in referring to traits or behavior tendencies that may be discussed under one or another of these headings. In German, according to Klages, there are 4000 words which have been employed to describe character qualities. (F. Baumgarten, "Die Charakterfestellung bei den Eignungsprüfungen," *Psychot. Z.*, 4 (1929), p. 113.) The author knows of no such count in English, but a survey of the literature suggests that there are probably as many in this language and that all have been employed by one or another author in the discussion of such traits. The author is inclined toward Roback's definition of personality as the *"intergrative combination of all our cognitive (knowledge), affective (feeling), conative (volitional), and even physical qualities."* (A. A. Roback, *Personality*, Cambridge, 1931, pp. 31–32. See also the *Psychology of Character*, New York, 1928, pp. 620.) *Temperament* is defined by the same author as the sum-total or blend of one's affective qualities as they impress others, and *character* as the conative part of personality coinciding with the volitional and inhibitory phases of behavior. Roback's definition of personality implies, of course, that any disturbance in the integration or balance of one or all of the factors may produce a personality maladjustment. (See Chapter XXVI.) Although favoring this general approach, the author, as in the case of competency, will again avoid any attempt to resolve disagreements in terminology, and, in the discussion of the results of individual investigators, will employ the concepts as used by them in the presentation of their material.

[74] P. M. Symonds, *Diagnosing Personality and Conduct*, New York, 1931, pp. 10–11.

[75] J. F. v.Foerster, "Über den Charakter und seine Berufswichtigkeit," *Ind. Psychot.*, 3 (1926), p. 88.

[76] F. Baumgarten, "Die Charakterfestellung bei den Eignungsprüfungen," *op. cit.*, p. 114.

fitness for the job.[77] Although there is much disagreement among psychologists with respect to the classification of such traits and tendencies, there is uniform accord on their importance. Watts, for example, stresses the instinctive basis of personality, in his insistence "that the vocational psychologist will need to take into consideration what has so far been overlooked, the instinctive make-up of the subjects of his experiments, and that in choosing workers for particular tasks he must make sure that their instinctive type is the right one. It would be folly," he adds, "to place the man with strong gregarious tendencies in lighthouse or wireless work, or advise him to go into farming in a new colony, just as it would be unwise to encourage a boy devoid of the acquisitive instinct to set up in business. And it will be agreed that a soldier or a reformer without a considerable spice of pugnacity would be a failure, while it is equally beyond dispute that the statesman and the priest, the doctor and the nurse, the teacher and the shepherd would soon tire of their work if they were not endowed strongly with the tender impulse." [78]

In contrast with Watts' emphasis on instinctive basis, is Bingham's hypothesis, based on Freyd's [79] and Hubbard's [80] studies of the interests of mechanically and socially inclined individuals, that "early introversion [81] of personality leads to the development, through disproportionate exercise, of one's native interests in mechanisms or ideas, at the expense of interest and proficiency in social contacts." [82] According to this viewpoint, the boy with only average native "mechanical ability," but with a tendency to introversion, resulting in part from childhood experiences, shrinks from social contacts and buries himself in play with mechanical contrivances. Original capacity for manipulation is enhanced with practice. Interest grows with skill. "Mechanical ability" is conditioned by personality. The bending of the twig toward introversion inclines the tree toward the mechanical—and the young

[77] A. Carrard, "Quelques Expériences sur l'Étude de la Personnalité," *Proceedings, VI-A Conferència Internacional de Psicotecnica*, Barcelona, 1930, p. 208.

[78] F. Watts, "The Outlook for Vocational Psychology," *Brit. J. Psych.*, 11 (1921), pp. 194–206.

[79] M. Freyd, "Introverts and Extroverts," *Psych. Rev.*, 31 (1924), pp. 74–87; "The Personalities of the Socially and Mechanically Inclined," *Psych. Monog.* No. 151 (1924), pp. 99.

[80] R. M. Hubbard, "Interests Studied Quantitatively: Measurement of Differences between the Socially and Mechanically Inclined in Relation to Vocational Selection," *J. Pers. Res.*, 4 (1926), pp. 365–378.

[81] The concepts of *introversion* and *extroversion* represent the contribution of Carl G. Jung, a Swiss psycho-analyst, to the classification of personality. Introverts are characterized by an outlet of emotion within themselves. The introvert is self-conscious, sensitive, easily embarrassed, careful of details, and shut-in. The extroverts find outlets for their drives in associating with others and in action. They are self-confident, talkative, sociable, adapt themselves easily to social situations, etc. The genesis of introversion, according to Jung, is largely associated with early childhood experiences. (See C. G. Jung, *Psychological Types*, New York, 1923, pp. 654.)

[82] W. V. Bingham, "Personality and Vocation," *Brit. J. Psych.*, 16 (1926), p. 359.

man becomes an inventor or an engineer instead of an actor, a salesman, or a business executive.[83] The findings of Laird, that foremen and executives tend to be extroverts, that inspectors, accountants, and research engineers are, in general, introverts, lends support to the viewpoint that personality traits at least influence vocational adjustment, even though they may not account for the origin of interest and competency.[84]

A somewhat different approach in indicating the influence of conduct tendencies upon working activities grows out of Kretschmer's classification of temperament on the basis of physical build.[85] Kretschmer recognizes two distinct types of temperament, the *cyclothymic* and *schizothymic.* The cycloids (having the former temperament) are characterized by wide fluctuations in mood, varying from one of joyful exhilaration to extreme depression (manic-depressive). The schizoid, on the other hand, is an unsociable, self-contained, quiet, serious, and occasionally eccentric individual.[86] The former tends to be expansive and social, the latter retiring and reserved, often concealing under a forbidding exterior a wealth of feeling and sensitivity. The influence of these distinctive temperaments on occupational activity is indicated in the following tabulation, showing the direction of interest and conduct on the part of individuals of both types engaged in the same field of work:

Relation Between Temperament in Occupation

(Kretschmer)

Occupation	*Cyclothymic Temperament*	*Schizothymic Temperament*
Poets and Authors	Realists Humorists	Sad Romantic Stylists
Investigators	Objective Empirical	Logical Systematic Metaphysical
Director or Executive	Boosters Enthusiastic Leaders	Pure Idealists Despots and Fanatics Cool, Calculating, Selfish Leaders [87]

[83] *Ibid.,* pp. 359–60.
[84] D. Laird, "How Personalities are Found in Industry," *Ind. Psych.,* 1 (1926), p. 660.
[85] E. Kretschmer, *Physique and Character,* New York, 1925, pp. 266.
[86] P. M. Symonds, *op. cit.,* p. 510.
[87] See E. Mira, "Tempérament et Caractère," *Ve Intern. Psychot. Conf.,* Utrecht, 1928 ("Symposia on Temperament and Character"), p. 14.

The importance of other aspects of temperament and character receives emphasis in the work of other students in this field.[88] Bathurst,[89] for example, stresses social adaptability as the temperamental factor requiring first consideration in the determination of vocational fitness. Mira [90] includes phobic signs, or tendencies toward abnormal anxiety and fears, sensorial hyperaesthesia (sensitivity), as criteria in determining the suitability of an individual for executive work, teaching, etc., for repetitive tasks of the manufacturing plant, and for artistic creation in the plastic arts. There is, as has been suggested above, much vague terminology, a great deal of loose thinking, and entirely too little concrete experimental evidence on the significance of particular traits. In spite of this, there is good reason for the opinion that fitness for an occupation is most certainly a function of the "instincts, emotions, temperament and character" [91] and similar traits and tendencies which must be duly weighted in vocational selection.

THE SIGNIFICANCE OF INTEREST IN VOCATIONAL FITNESS

Interest in the activities of a particular job is among the factors to be considered in determining fitness for work. There seems reason to believe that unless the individual "likes the activities of the job," unless they awaken in him a "feeling of pleasantness," and he is "attracted toward them," he may be unhappy in his work, even if he has the requisite skill and competency and his efficiency remains undisturbed. Common opinion, at least, holds that "without interest, work is colorless and drab; with interest, work seems worthwhile to the individual; abilities are developed, and accomplishments are realized." [92]

The Meaning of Vocational Interest

The experimental investigation of the significance of interest in adjustment is complicated by two factors: (1) *wide variations in the conceptual treatment of interest,* and (2) *the question of the relationship between interest and ability. On the one hand,* interest has been conceived as an expression of feeling or a reaction toward the operations of a particular task and, *on the other,* as a complex of all the drives which underlie a worker's attitude toward his work, toward the plant, and perhaps toward industrial civilization in its entirety. Between these two extremes are many grades and variations of interest definition—subjective and objective—involving the employment of many diverse criteria for the observation and measurement of interests. At

[88] See J. P. Porter, "The Study of Personality Factors in Psychotechnique," *Proceedings, VI–A Conferència Internacional de Psicotecnica,* Barcelona, 1930, pp. 123–131.

[89] J. E. Bathurst, "Emotional Specifications and Job Happiness," *Ind. Psych.,* 3 (1928), pp. 520–525.

[90] E. Mira, *op. cit.,* pp. 14–16.

[91] *Ibid.*

[92] D. Fryer, *Measurement of Interest,* New York, 1931, p. 189.

one extreme is Kitson's proposal for studying interest in a specific occupation by a rating scale which invites the subject to "think of that activity in which you would spend your time if you had a million dollars and were not obliged to work." [93] At the other are Strong's [94] and Cowdery's [95] inventories of "like," "indifference," and "dislike," with respect to many types of activities and people, ranging from "fat man" to "playing golf," from reading activities to preference for directed or undirected work—as means of gauging the identity of interests of the individual with those of others in a specified occupation. Free association tests,[96] information tests,[97] learning and distraction tests,[98] each growing out of a somewhat distinctive definition of the nature of interest, bear further evidence to the diversity of concepts developed by investigators in the field of interests.

Fryer has recently reviewed these various treatments and arrived at an *acceptance-rejection theory* of interest measurement which identifies objective interests as acceptance reactions, in contrast to aversions, which are rejection reactions. Subjective interests or "likes" in this theory are associated with acceptances of stimulation, and subjective aversions or dislikes with rejections of stimulation. The development of this theory leads to a definition of interest and motivation as separate in mental life, motivation being defined as the degree of stimulation, and interest as the quantitative feeling of pleasantness or unpleasantness associated with the acceptance or rejection of the stimulation. A further elaboration of this point of view leads to a classification of interests in terms of the "objects and activities, of the psychological stimuli which engage the attention of the individual." [99] The acceptances and rejections are observed both in reactions of the individual and in his estimations of pleasure and displeasure when stimulated by an interest situation.

This point of view, although standardizing the concept of interest,

[93] H. D. Kitson, "Investigation of Vocational Interest Among Workers," *Psych. Clin.* 19 (1930), pp. 48–52.

[94] E. K. Strong, "An Interest Test for Personnel Managers," *J. Pers. Res.*, 5 (1926), pp. 194–203; "Interest of Engineers, A Basis for Vocational Guidance," *Pers. Jour.*, 7 (1929), pp. 441–454; "A Vocational Interest Test," *Educ. Rec.*, 8 (1927), pp. 107–121; "Vocational Guidance of Executives," *J. App. Psych.*, 11 (1927), pp. 331–347; "Diagnostic Value of the Vocational Test," *Educ. Rec.*, 10 (1929), pp. 59–68; "Procedures for Scoring an Interest Test," *Psych. Clin.*, 19 (1930), pp. 63–72.

[95] K. M. Cowdery, "Measurement of Professional Attitudes; Differences between Lawyers, Physicians and Engineers," *J. Pers. Res.*, 5 (1926), pp. 131–141.

[96] J. B. Wyman, "Measurement of Interest," *Vocational Guidance Magazine*, 8 (1929), pp. 54–60.

[97] H. A. Toops, "Tests for Vocational Guidance of Children Thirteen to Sixteen Years of Age," *Cont. to Educ.* No. 136, New York, 1923, pp. 159, and H. E. Burtt and F. Ives, "Vocational Testing for Agricultural Engineers," *J. App. Psych.*, 7 (1923), pp. 178–187.

[98] H. E. Burtt and F. Ives, *op. cit.* See also H. E. Burtt, *Employment Psychology*, Boston, 1926, pp. 568.

[99] D. Fryer, *op. cit.*, pp. 15–16.

still permits wide-spread diversity of opinion with respect to the meaning of vocational interest, depending upon whether the investigator views the conditions of work as the motivating situation, that is, the total pattern of the job, the conditions in the plant, the system of wage payment, etc., or whether he is referring specifically to the operations and organization of activities of the job without reference to the general situation in which the job is done. For the purposes of this text vocational interest, or perhaps more narrowly *job interest,* refers to the individual's like for the tasks he is required to perform in the industrial plant. It refers, for example, to his acceptance or rejection, his like or dislike of a job in which he performs the same single operation again and again throughout the day in comparison to his subjective and objective reactions to a job characterized by greater variety in the sequence of operations. The significance of *job interest,* when oriented from this viewpoint, will be further discussed below.

The Relation Between Interest and Ability

Another complicating factor in the consideration of interest as a factor in vocational fitness is the question of the relationship between interest and ability. The early point of view of this question has been expressed by Woodworth in his statement that "human interests keep pace with human capacities. Almost always," he writes, "where a child displays talent, he also displays interest. It might not be amiss to extend McDougall's conception of the connection of instincts and emotions so as to speak of a native interest as the affective side of a native capacity. Along with the capacity for music goes the musical interest; along with the capacity for handling numerical relations goes an interest in numbers; along with the capacity for mechanical devices goes the interest in mechanics; along with the capacity for language goes the interest in learning to speak; and so on through the list of capacities, both those that are generally present in all men and those that are strong only in the exceptional individual." [100]

More recent experimentation has led to marked skepticism concerning the positive character of the relationship between interest and ability. Studies of "successful" and "unsuccessful salesmen", by Ream,[101] Craig,[102] and Freyd,[103] show no group interest or interests which invariably distinguish successful from unsuccessful salesmen, and reveal no consistent relationship between interest and degree of accomplishment in this vocation. Other investigations, involving a comparison of interest and ability both by means of estimations and by in-

[100] R. S. Woodworth, *Dynamic Psychology,* New York, 1922, p. 74.

[101] M. J. Ream, *Ability to Sell,* Baltimore, 1924, pp. 64 ff.

[102] D. R. Craig, "The Preference of Interest Questionnaire in Selecting Retail Saleswomen," *J. Pers. Res.,* 3 (1925), pp. 366–374.

[103] M. Freyd, "Selection of Promotion Salesmen," *J. Pers. Res.,* 5 (1926), pp. 142–146.

terest inventories likewise show no significant relationship between interest and ability regardless of whether general intelligence, mechanical ability, or other criteria are employed as the standards of ability.[104] The research in this field "suggests that the relationship between all interests and abilities is so low that subjective interest cannot be used for the prediction of abilities. . . . The research upon the relationship of abilities and interests suggests the conclusion that interests and abilities are different qualities in mental life. Neither one is dependent upon the other. Neither can be predicted from the other." [105]

In view of the evidence of such studies that interest has little or no influence upon achievement, the question may be raised as to the need of considering interest in determining fitness for work. This question is easily answered if one accepts *satisfaction* and *economic efficiency* as independent criteria of adjustment in work. Viewed from this angle, interest in the activities of the job becomes an important criterion in determining the suitability of a worker for a job. The significance of this standard is very well brought out in English investigations of monotony, which show that a dislike for a repetitive job definitely affects the adjustment of workers who are superior from the viewpoint of competency for the work.[106] So, for example, girls with higher levels of intelligence maintain a higher level of production on certain repetitive jobs than those with lower levels of intelligence, but a pervading feeling of unpleasantness and of ennui, accompanied by changes in the shape of the daily work curve, attest to the absence of interest on the part of the former in the operations of the job at which they are employed. Job interest is revealed here as a factor distinct from other variables affecting adjustment in work. It is far from being the only factor in susceptibility to monotony, but the rejection of the task, and the feeling of unpleasantness, are definitely major items in this situation. Fairchild [107] has also recently shown that the "skill" becomes a first source of satisfaction in work in jobs offering an opportunity for its display. In this case, too, a liking for the activity of the job must be considered as one element in the development of the more generalized feeling tone which may be described as satisfaction in work.[108] From this viewpoint, job interest must be considered important in

determining fitness at work; and its measurement, as a separate entity, becomes a distinct problem for the psychologist interested in the happiness of the worker as well as in his economic efficiency in the industrial organization.

IX. JOB ANALYSIS

THE SCOPE OF JOB ANALYSIS

The first step in fitting men to jobs, and in maintaining fitness at work, is to make a comprehensive study of occupational activities and requirements. No employment manager can hope to make a proper selection of workers without a thorough knowledge of the duties and conditions of work of the job to be filled and of the human capacities essential to success in it. No satisfactory training program can be devised unless there is available exact information concerning the operating techniques employed on the task. The elimination of unnecessary fatigue, the reduction of accidents, the improvement of motivation, etc., require an exact knowledge of working conditions which may affect these variables. The procedure of obtaining such information is known as *job analysis*,[1] defined as "the scientific study and statement of all the facts about a job which reveal its content and the modifying factors which surround it." [2] It involves a "determination of the essential elements in the job and the qualifications a worker should have for its successful performance." [3]

The *techniques* employed in job analysis will depend in large part upon its purpose. So, for example, where attention is centered upon training, time and motion study techniques and other specialized procedures for the analysis of skill must be employed.[4] A concern for fatigue effects may lead to a classification of work with respect to daily

[1] The terms *job* and *job analysis* have been used in a variety of senses. Kitson, for example, distinguishes among *vocational analysis*, or the study of an entire profession or trade, e. g. physician; *occupational analysis*, or the study of a specialized occupation within a trade, e. g. eye-doctor; and *job analysis*, or the study of a particular operation, e. g. winking the eye. (H. D. Kitson, *The Psychology of Vocational Adjustment*, New York, 1925, p. 25.) The term *occupation analysis* is used by English investigators to include every kind of inquiry that the study of employment entails ("Occupation Analysis," Nat'l Inst. Ind. Psych., *Report* No. 1 (1926), p. 1). In American industry, in spite of Kitson's classification, the term job is used to describe a self-contained unit of work performed by the individual worker, be it as routine as that of the punch press operator or as varied as that of the pattern maker or private secretary. Occupation is sometimes used as a synonym for this, but more frequently as a comprehensive term including many allied jobs. Vocation is almost invariably used in an even more general sense to refer to a great number of similar but independent working activities, e. g. the vocation of business, of engineering, etc.

In this volume the term *job analysis* will be used to refer to the procedures employed in gathering information about work activities and their requirements in the way of personnel, regardless of whether vocation, occupation, or job is the unit under observation.

[2] O. Tead and H. C. Metcalf, *Personnel Administration*, New York, 1920, p. 255.

[3] J. D. Hackett, *Labor Management*, New York, 1929, p. 161.

[4] See Chapter XX, pp. 433–37 and Nat'l Inst. Ind. Psych., *Report* No. 1, pp. 15–19.

caloric consumption,[5] in the manner of Slosse and Waxweiler,[6] who have divided 81 occupations into 3 groups, *light, heavy,* and *very heavy,* on this basis (2450–3100; 3400–3800; 4050–5300 calories respectively). The same interest may favor the type of analysis employed by Amar,[7] who has considered body activity in classifying working activities into those involving primarily (a) body weight, (b) arm musculature, (c) leg musculature, and (d) miscellaneous operations, including those requiring finger movements. In general, as Meine [8] has pointed out, job analysis can be classified into four types with respect to purpose:

1. *Job analysis for the purpose of improving working methods and processes.*
2. *Job analysis for the purpose of protecting health and safety.*
3. *Job analysis to be used as a basis for training employees.*
4. *Job analysis to be used for employment purposes,* i. e., (a) in selecting, transferring, and promoting employees, and (b) in establishing wage schedules.

JOB ANALYSIS FOR EMPLOYMENT PURPOSES

The discussion in this chapter will be confined to the last type of job analysis. The analysis of jobs for employment purposes is limited to a determination of the *actual* duties and working conditions and the qualifications of the man who is to do the work. The analysis may or may not presuppose the existence of previously established performance standards. The job is described as it is found, a selection being made of such available information about the job as is pertinent in placing workers. This may incidentally contribute toward setting up more effective ways of work, improvement in shop standards, etc., but the chief purpose of the job analysis for employment purposes is the accumulation of data that may be useful in hiring new workers and in transferring and promoting older employees.[9]

Information obtained in the analysis of individual jobs for selection purposes is embodied in a *job specification.* Every job specification has two aspects—a *job* aspect, or description of the features of the work, and a *man* aspect, consisting of a detailed description of the necessary physical and mental characteristics of the worker. The job specification when completed may be presented either in the form of a running statement [10] or be summarized on a special form or check sheet, illus-

[5] See Chapters XXI and XXII.

[6] A. Slosse and E. Waxweiler, *Enquête sur l'alimentation de 1065 ouvriers Belges,* Paris, 1910, pp. 57 ff.

[7] J. Amar, *Le Moteur humain et les Bases scientifiques du Travail professionnel,* Paris, 1923, pp. 565.

[8] F. Meine, "Job Specifications," Federal Board for Vocational Education, *Bulletin,* No. 45 (1919), pp. 30. F. Meine, "Job Analysis for Employment Purposes," *Ann. Amer. Acad. Pol. Soc. Sci.,* 110 (1923), pp. 22–31.

[9] *Ibid.,* p. 24.

[10] See "Trade Specifications and Index of Professions and Trades in the Army," *War*

trated on pages 151–53,[11] which makes more readily available the information concerning the job which the employment manager or the investigator in industry should have. There is no uniform agreement among investigators with respect to the items to be included in a job specification.[12] There are wide differences, in so far as completeness is concerned, among those which have been prepared in independent studies. The following list, used by the author as a guide in job analysis,[13] includes the variety of factors which should be considered in a comprehensive analysis and statement of the characteristics of the job and of the worker for employment purposes:

GUIDE TO JOB ANALYSIS

1. *Identification of the Job.*
2. *Number Employed.*
3. *Statement of Duties.*
4. *Machines Used.*
5. *Analysis of Operations.*
6. *Conditions of Work.*
7. *Pay and Non-Financial Incentives.*
8. *Relation to Other Allied Jobs.*
   (Place in the organization)
9. *Opportunities for Transfer and Promotion.*
10. *Time and Nature of Training.*
11. *Personnel Requirements.*
    (a) General, e. g., Age, Sex, Nationality, Marital Status, etc.
    (b) Physical
    (c) Educational
    (d) Previous Experience
    (e) General and Special Abilities
    (f) Temperamental and Character Requirements.

Dept. Doc., No. 774, Washington, 1918, and "Descriptions of Occupations," *U. S. Dept. of Labor*, Washington, 1918–1919.

[11] F. Meine, "Job Analysis for Employment Purposes," *Ann. Amer. Acad. Pol. and Soc. Sci.*, 110 (1923), p. 25.

[12] For a discussion of items see W. V. Bingham and M. Freyd, *Procedures in Employment Psychology*, New York, 1926, pp. 15–17; F. Meine, *op. cit.;* R. C. Clothier, "An Occupational Survey," *J. Pers. Res.*, 2 (1923), pp. 427–50; E. J. Benge, "What Items Should the Job Specification Include," *Ind. Mgt.*, 59 (1920), p. 330; J. O. Hopwood, "Fundamentals in Salary and Wage Administratiton," Am. Mgt. Assoc., *Office Mgt. Series*, No. 55 (1930), pp. 16–20; C. S. Myers and others, "Occupation Analysis," Nat. Inst. Ind. Psych., *Report*, No. 1 (1926), p. 36; F. Baumgarten, *Die Berufseignungsprüfungen*, Munich, 1928, pp. 80–137; J. Fontègne, *L'Orientation Professionnelle*, Paris, 1921, pp. 76–103; O. Tead and R. B. Gregg, *Outline of Job Analysis*, New York, 1918, pp. 160; M. S. Viteles, "Job Specifications and Diagnostic Tests of Job Competency Designed for the Auditing Division of a Street Railway Company," *Psych. Clin.*, 14 (1922), pp. 83–105; W. Ruffer, "Schema ein Fähigkeitsanalyse für kaufmannische Büroangestellte in der Verwaltung eines Grossbetriebes," *Ind. Psychot.*, 5 (1928), pp. 345–58.

[13] M. S. Viteles, "Job Specifications and Diagnostic Tests of Job Competency, etc.," *Psych. Clin.*, 14 (1922), pp. 83–85.

12. *Special Advantageous or Disadvantageous Features.*
13. *Employment Conditions.*

Sources of Information in Job Analysis

In the preparation of job specifications the investigator can make use of a number of available sources of information. The best of these is observation in the course of actual work at the job. This procedure has been followed by Link [14] in analyzing the job of assembling gun parts, by the author in the study of motormen and of electrical substation operation,[15] and by other investigators. Actual practice on the job is particularly suitable for occupations requiring only short training periods. It is especially desirable in the case of all jobs involving manipulation, where the observation of movements gives little clue to the underlying abilities, skills, and attitudes evoked by the performance. So, for example, Rupp points out that the activity of "halving" a short line differs both objectively and subjectively from that of "halving" a long line,[16] and that observation gives no clue to the character of such differences.

In addition to practice on the job, and wherever such practice is impossible, the investigator can use such secondary sources as observation of workers employed on the task, photographic and similar devices, interviews with workers and supervisors, questionnaires, output and turnover records, changes in employment conditions, and the large body of literature which is being gradually built up in this field. However, although the investigator may be forced by circumstances to depend upon such secondary sources, these cannot completely take the place of first-hand contact with the work and direct association with those engaged in it as a means of obtaining adequate information.

THE PSYCHOLOGICAL VIEWPOINT IN JOB ANALYSIS

In general, job specifications as ordinarily developed in industry suffer from a number of serious defects. In the first place, many of them are limited almost exclusively to a description of the duties and working conditions. In many instances the statement of personnel requirements is restricted to a general description of such factors as age, sex, health—no attempt being made to designate the mental capacities and other traits essential for success on the job. In other cases, an attempt is made to describe such traits, but they are stated in vague, abstract terms which only confuse the problem of personnel qualifications. So, for example, the qualifications for a power press operator are described as "good muscular co-ordination and of such order of

[14] H. Link, *Employment Psychology*, New York, 1919, p. 55.

[15] M. S. Viteles, "Research in the Selection of Motormen," *J. Pers. Res.*, 4 (1925), pp. 100–15, 173–99; and "The Human Factor in Substation Operation," *Pers. J.*, 8 (1929), pp. 85–86.

[16] F. Baumgarten, *op. cit.*, p. 117.

intelligence as is satisfied and inclined to reduce its work to terms of continuous, single-grooved habit (*sic*). As a natural corollary it is obvious, therefore, that an over-responsive, over-keyed, nervous organization would be dangerous, on account of accidents, and would also make the work disagreeable, and hence, not a 'good job' from employee's standpoint. To make for a permanent force, other things being equal, it is very essential that the intelligence be not overactive or imaginative, and that the employe be such as would consider himself acquiring nothing beyond his expected stipend and the knowledge of running that kind of machine. As a general proposition he must be plastic enough to fit into the spirit as required above by definition of a foreman and, therefore, not 'fresh or a smart Aleck.' " [17] In somewhat the same way the qualifications of a librarian are described as follows: "A love of reading is not a major qualification since a librarian has little time for reading. She needs accuracy, quickness, neatness, a pleasing appearance, and the application necessary to do much routine work. All these qualities must be founded upon a sincere and active enthusiasm for the library work. . . . For advancement . . . she must constantly be her own teacher in assimilating current information. She must possess a liking for people with a natural desire to assist them. The executive must have breadth of vision. Scholarliness would be another fundamental." [18]

The outstanding weakness in such statements of qualifications is the failure to define the terms used in describing traits necessary for success. Qualifications are stated in vague terms, almost incapable of exact definition and conveying entirely different ideas to different readers. In addition, there is a failure to rate these traits quantitatively. There is no indication of the degree of each quality necessary for success and the relative importance of each. So vague and indefinite is this presentation that in many such descriptions the title of another occupation could be substituted for the one being described without affecting the impression on the reader. In the description of the mental qualifications for librarian quoted above, the jobs "office worker," "teacher," "cashier in a department store," "scraper of celery in a soup factory," could be substituted for "librarian" without affecting the applicability of the description.[19]

Where capacities for success are to be stated in terms of mental traits there must be substituted for such vague qualities as "accuracy," "quickness," "mechanical ability," "initiative," and other ill-defined mental characteristics a category of specific mental abilities which are involved in each vocation. Moreover, the description of the motive

[17] R. J. Burke, "Written Specifications for Hiring," *Ann. Amer. Acad. Pol. Soc. Sci.*, 115 (1916), pp. 179–180.

[18] F. B. Jennings, *The Librarian*, The White-Williams Foundation, Monog. Series No. 2, Philadelphia, 1923, p. 5.

[19] M. S. Viteles, "Vocational Guidance and Job Analysis: The Psychological Viewpoint," *Psych. Clin.* 15 (1924), p. 164.

concepts, or concepts of temperament, such as "loyalty," a "sense of responsibility," "patience," "tact," "good manners," etc., must be treated separately from the description of the specific mental abilities which underlie job proficiency.

It is necessary not only to define carefully the specific mental traits which are required in a given occupation, but to indicate the extent to which each is involved in the working activity. In many cases the difference in competency between two jobs consists not in a difference in the number and kind of specific mental abilities for which each occupation calls, but in the extent to which each ability is called forth in the occupation, and in the relation among them. The difference is not one of *content* but of *pattern*—an emphasis in one job of certain specific mental traits which are not emphasized in the second.[20]

Before proceeding with a discussion of psychological techniques in job analysis, it is perhaps well to summarize briefly the chief contributions which industrial psychology can make toward a more adequate analysis of personnel qualifications. One important contribution is that of *emphasis*. This includes an insistence upon a much more detailed study of personnel requirements than is characteristic of lay investigations in this field. Attention is directed to the psychological aspects of work, to an analysis of all mental traits and behavior patterns which determine success at work.[21] The emphasis in the psychological study of occupations is not alone on scope, but also upon the *specific, concrete,* and *quantitative* description of the activities and requirements of the job.[22]

The second contribution of psychology to job analysis is in the way of improved *methods*. These grow out of an application to job analysis of rating scale techniques, specialized methods for the analysis of skill, the detailed observation of behavior, and testing and other procedures characteristic of psychological investigations in other fields.

PSYCHOLOGICAL TECHNIQUES IN JOB ANALYSIS

The Individual Psychographic Method

The earliest attempt to differentiate occupations on the basis of special aptitudes and other personal characteristics took the form of a careful and detailed study of men who achieved outstanding success in their chosen occupations. Family history, individual development, sensory acuity and discrimination, memory, language ability, imagery, reaction time, habits, opinions, etc., were considered in analyzing the psychological foundations of success. Interviews, observation, and tests were employed in completing the analysis, the findings being combined into an *individual psychograph* or clinical picture of the particular in-

[20] *Ibid.*, p. 165.
[21] C. S Myers and others, *op. cit.*, p. 15.
[22] F. Meine, *op. cit.*, pp. 27–29.

dividual. Subjected to such an analysis, Zola, the famous French novelist, was found, by Toulouse,[23] to be "characterized by prominent voluntary intellectual activity, clearly conscious and intense, concentrated in effort, with no tendency to perserveration of ideas after cessation of work. His thought, as disclosed by the tests, was logical, methodical, and (in spite of his actual vocation) seemed pre-eminently fitted for the work of mathematical deduction."[24] The study, by the same method, of J. Henri Poincaré, the noted French mathematician, revealed such traits as a "tendency to automatisms and the perserveration of psychic activity," "prominent muscular reflexes," "uncertainty, irregularity and awkwardness of movement," "flighty attention," "exceptional memory capacity," etc.[25]

In general, the individual psychographic method has yielded little information of value in determining why certain individuals are more successful in their work than others, or in revealing the psychological requirements of particular work. A similar study of a large group of workers exhibiting varying proficiency on the same job may be useful in the analysis of these requirements. The analysis by tests, described below, represents essentially an application, on a restricted scale, of this point of view. However, the exact determination of the traits necessary for success in work requires that attention be centered not upon the individual, but upon the working activity—on the operations of the job at which the individual is engaged. In such an analysis "the work, rather than the worker, is made the object of the analysis."[26] This point of view is particularly important in the so-called "lower" or less complex occupations, where perhaps only a limited number of traits and behavior tendencies of the individual are called into play to determine both adjustment and efficiency at work.

The Questionnaire Method in Job Analysis

Diverse procedures have been employed in the study of the job for identifying the qualifications for particular jobs. Among these is the *questionnaire method,* first employed, in 1916, by Lipmann,[27] who sent a sheet containing 86 questions to individuals, organizations of workers, and others interested in vocational placement and training, in an attempt to arrive at a satisfactory classification of the characteristics of diverse occupations. This list was extended in 1917 to include 105 questions and at a still later date elaborated into 148 questions concerning the psychological traits necessary for different types of

[23] E. Toulouse, *Enquête Médico-psychologique sur les rapports de la supériorité avec la névropathie,* Paris, 1896.

[24] H. L. Hollingworth, *Vocational Psychology and Character Analysis,* New York, 1929, p. 242.

[25] *Ibid.,* pp. 238–41.

[26] *Ibid.,* p. 244.

[27] O. Lipmann, "Zur psychologischen Charakteristik der 'mittleren' Berufe," *Z. f. ang. Psychol.,* 12 (1916), pp. 99–107. See also J. Fontegne, *L'Orientation Professionnelle,* Paris, 1921, pp. 95–101.

work, and applied by Lipmann to 121 distinct occupations. Those answering the questionnaire were asked to indicate (1) whether each of a number of specific traits was indispensable, desirable, or unnecessary; (2) whether it was frequently, occasionally, or never involved in the performance of duties; and (3) whether it was much, slightly, or not at all improved by training. The following are characteristic of the items on which ratings were requested:

1. *To perceive objects without easily distinguished characteristics, feebly illuminated, and to recognize and to distinguish them rapidly from others.*

15. *To discriminate exactly at great distances the speed and direction of moving objects, acceleration of movement, and diminution of speed.*

26. *To read quickly and easily.*

49. *To adapt the rhythm of one's movements to a given tempo.*

55. *To execute at the same time different movements with different members of the body.*

64. *To concentrate attention.*

72. *To change the nature of the work frequently and to adapt oneself easily each time to the new work.*

85. *To criticize one's own work.*

A somewhat similar procedure has been followed by Ulrichs [28] in the determination of the mental characterisuics of the so-called "higher professions." In this case the questionnaire was designed to include qualities particularly significant in occupations at this level, classified under such headings as (a) *physical aptitudes;* (b) *psychophysical aptitudes,* subdivided into movement appropriate to an end, movement of expression, etc.; (c) *mental aptitudes,* such as observation, attention, imagery; and (d) *adaptability,* including such items as fatiguability, motivation, social talents, etc.

The chief contribution in this approach lies in the attempt to state in more explicit terms the actual behavior and the psychological traits to be considered in the analysis of occupations, and to provide a method for rating them. At the same time the traits listed remain somewhat complex and general in character, and are in no sense mutually exclusive. The chief weakness in this procedure is the method employed in obtaining information concerning the importance of specific traits. Replies given by workers on a questionnaire can hardly be accepted as an accurate statement of the requirements of the job. Supplied by observers untrained in the method of exact observation, the answers can be assumed to have little validity in accurately describing the qualifications involved in work.

[28] M. Ulrichs, "Die psychologische Analyse der höheren Berufe als Grundlage einer künftigen Berufsberatung," *Z. ang. Psy.*, 13 (1918), pp. 1–36. See also *Schr. Ps. Beruf. Wis.*, Leipzig, 1917, No. 5.

The Job Psychographic Method

The scientific study of occupational qualifications requires (1) a simplified classification of specific mental traits; (2) a standard rating technique; and (3) a direct examination of work activities by trained observers. These criteria have been applied by the author in the development of a job *psychographic method* in job analysis.[29] The terms used for designating mental abilities essential for success in the application of this method are shown on page 153. The following descriptions illustrate how these traits are defined:

2. *Rate of Discharge.* By this is meant the *speed* with which energy must be expended on the job. In some jobs, such as that of the longshoreman, much energy is needed, but it is discharged slowly, while in others much energy must be expended with great speed, as in emergency work on overhead lines. On the other hand, there are jobs in which the energy demand is low, and energy may be expended at either high or low speed.

6. *Co-ordination* (B). This refers to the harmonious combination of visual and muscular functions on the job. It is movement controlled by sight. It is important, for example, in such a job as telephone operating, in which the operator is required to place a plug into a hole of small diameter, the location of which is perceived through the eye. At the other extreme is that of loading crates or bales into a box-car, in which Co-ordination B is a negligible factor.

25. *Observation.* By this is meant the ability of directing attention so that no detail of the performance remains unnoticed. The individual must always be aware of what he is doing, continuously giving heed to the minute details of his job activity or surroundings. The job of proof-reading, for example, would be rated high on observation because it is necessary for the proof-reader to notice every small detail of the copy. This is likewise true of most inspection jobs. Copying from rough draft would also be rated high on observation, although not quite as high as proof-reading. In such a job as shoveling, observation would be rated low.

In using this method in job analysis each trait is rated on a 5-point scale to designate the extent to which it is essential for success on the job, the value of each point being as follows:

1. *Negligible*
2. *Barely significant*
3. *Significant*
4. *Of great importance*
5. *Of utmost importance*

The ratings are graphically recorded on a form such as that shown on page 153. A line connecting the X's on the chart gives a *job psychograph.* If the form is held so that the specific abilities come at the bottom of the sheet and the curve strikes horizontally across the page,

[29] M. S. Viteles, "Job Specifications and Diagnostic Tests of Job Competency Designed for the Auditing Division of a Street Railway Company," *Psych. Clin.*, 14 (1922), pp. 83–105.

the *peaks* of the curve reveal at a glance the specific mental abilities which, in the opinion of the one who is making the job analysis, are most essential in job success. These abilities can be called the *"keystone" specific mental abilities,* related to the "keystone" operations of the job or the activities which most clearly distinguish it from other, similar jobs. It is these keystone abilities which must be particularly tapped when the analytic type of test is used in predicting success on the job,[30] for it is the possession of these, to the extent required by the job, which primarily determines the individual's fitness for the work.

The job psychograph shown on page 153 is that of a *quiller* in the textile industry. An examination of this, in comparison with the material shown on pages 151–52, reveals the relationship of the job psychograph to other data on the characteristics and requirements of the job which should be included in a complete job specification. The job psychograph is that part of the job specification which shows the requirements in the way of *mental ability.*

Job Analysis by Test

Subjective methods for analyzing the mental requirements of a job, such as those described above, have been supplemented by the more objective techniques of describing qualifications solely in terms of aptitude tests used in predicting the proficiency of an applicant for employment on the job. This method, which has been particularly advocated by Link, "makes a thorough-going analysis of one job and then, on

JOB SPECIFICATION NO.

Name of Job: QUILLER *Department:* COTTON WINDING *Number Employed:* 15

DUTIES:

1. Twist in the new warp to the old one.
2. Set the guides right.
3. Keep the warp straight and see that the ends are running on properly.
4. Doff, i. e., take off the bobbins.
5. Put on new bobbins.
6. Oil and clean machine.
7. Straighten out ends with a big lease.
8. Put on new bands whenever needed.
9. Take out tangles and twists of the warp.
10. Take out tangles of the yarn and smashes against the reeds.
11. Watch for double ends; remove and tie over if any occur.
12. Make sure that the machine is regulated properly.

[30] See Chapters VIII, pages 129-33, and XII, pages 225-30.

[31] Taken from E. Cades, "The Textile Industry in Philadelphia," *Psych. Clin.,* 15 (1924), pp. 203–228, a study made under the supervision of the author. See also C. L. Wood, "The Printing Trade in Philadelphia," *Psych. Clin.,* 15 (1924), pp. 182–202.

NATURE AND CONDITIONS OF WORK:

Hours from 7 to 5:30, Saturday from 7 to 12. Overtime *None.*
Piece rate: Pay beginning at . . . per . raised after to . . and after . . to . . .

Temporary	. . .	Permanent	X	Hot	. . .
Heavy	. . .			Steamy	. . .
Coarse	. . .	Fine	very	Wet	. . .
Dirty	. . .	Clean	X	Dusty	. . .
Standing	X	Sitting	. . .	Routine	. . .
Noisy	X	Quiet	. . .	Varied	. . .
Walking	X	Manual labor	. . .	Illumination	fair
Stooping	X	Clerical	. . .	Ventilation	fair
Lifting	. .	Operative	X	Cement floor	X
Pulling	X	Mechanical	. . .	Wooden floor	X
Pushing	. . .	Counting	. . .	Wet floor	. . .
Jerking	. .	*Tying knots*	X		

MACHINES USED:

Quilling machine

TIME TO LEARN AND NATURE OF TRAINING: Helper for 2 weeks. Twisting in twisting chair, etc. Can learn in 3 months. May become a fair operator in 6 months.

PROMOTION from skein winding to . . . . *no plan* . . . .

ALLIED JOBS: Skein winding.

ADVANTAGES: Good pay, clean work.

DISADVANTAGES: Mostly standing work; requires careful, constant application.

REMARKS: This quilling is on various colored yarns. Quilling in Mercerizing Department is all white and generally heavier yarn.

QUALIFICATIONS

GENERAL
Sex—Female
Age Limits—16 to 25
Preferred Age—18 to 22
Race and Nationality—
White American born

COMPETENCY
Special Traits

Distribution	5
Persistence	5
Observation	5
Co-ordination A	4
Vis. Disc.	4
Alertness	4

EDUCATIONAL

None	. .
Read	X
Write	X
Add & Sub.	. . .
Fractions	. . .

EXPERIENCE
Required—none
Desirable—
Work with yarn

PHYSICAL
Height—
Preferably medium height or over
Weight—
Medium
Preferably right handed
Endurance X
Power . .
Eyesight good
(Normal or corrected vision)

TEMPERAMENTAL
Patience
Carefulness

JOB PSYCHOGRAPH

Job: QUILLER *Department:* COTTON WINDING

	1	2	3	4	5	Remarks
1. Energy		X				
2. Rate of Discharge	X					
3. Endurance			X			
4. Control			X			
5. Co-ordination A				X		
6. Co-ordination B		X				
7. Initiative			X			
8. Concentration		X				
9. Distribution (of attention)					X	
10. Persistence					X	
11. Alertness				X		
12. Associability		X				
13. Visual Discrimination				X		
14. Auditory Discrimination		X				
15. Tactual Discrimination			X			
16. Kinaesthetic Discrimination			X			
17. Space Perception	X					
18. Form Perception		X				
19. Accuracy	X					
20. Visual Memory	X					
21. Auditory Memory	X					
22. Kinaesthetic Memory	X					
23. Understanding		X				
24. Understanding Q		X				
25. Observation					X	
26. Planfulness	X					
27. Intelligence			X			
28. Intellect		X				
29. Judgment	X					
30. Logical Analysis	X					
31. Language Ability	X					
32. Executive	X					

the basis of this study, selects a set of tests which seem to involve the same ability as that required by the job. These tests are then tried out on a larger number of workers whose ability is known in order to find those tests which do this to the highest degree. When tests which

are sufficiently significant are found, the result is a standard and scientifically accurate measurement of those specific abilities which are required by that specific job. *It is unnecessary to name these abilities.*[32] The qualities required by a successful inspector, for instance, need not be called good visual discrimination, quick reaction time, and steady attention. These names are general and serve merely as a starting point. The requirements of this job may be stated simply as the *ability to reach such and such a standard in tests number 2, 6 and 8.* There is nothing vague, abstract, or general about an analysis of this kind, any more than there is about the chemical formula *Hn03* (*sic*), or the formula in physics, $Mass = \frac{\text{weight in lbs.}}{32.16}$. The job has been analyzed in a scientific manner, in such a way that the abilities required by that job can be definitely and mathematically gauged." [33] This procedure has actually been followed by Link, who lists the qualifications for inspectors as:

Tests *No. 33.* Shock Absorber (A preliminary test to place the applicant at ease).

No. 1. Eye Test
No. 6. Cancellation
No. 8. Number Group Checking Test
No. 2. Card Sorting.[34]

Somewhat the same procedure has been followed by O'Connor,[35] who for purposes of vocational guidance has expressed the requirements for success in each of a variety of jobs in terms of a short battery of tests, without, however, adequately evaluating the battery with respect to its validity in predicting success for the job. The procedure of job analysis by tests finds its most logical development and elaboration in the proposal of Hull [36] for the construction of a single universal battery of tests, consisting of perhaps 30 or 40 different test units, for sampling all important aptitude determiners. Upon the basis of this battery there would be developed separate forecasting formulae for each of the 40 or 50 more important type occupations. In this way there would be 40 or 50 different equations each weighting the combined tests of the single battery in a different way so as to make the best possible forecast of a particular aptitude. In order to facilitate computation of these equations, Hull recommends the use of a calculating machine, devised by him, capable of automatically making one aptitude forecast after another until the entire 40 or 50 have been calculated for the single

[32] Italics by the author.
[33] H. C. Link, *Employment Psychology,* New York, 1919, p. 259.
[34] *Ibid.,* pp. 405, 414.
[35] J. O'Connor, *Born That Way,* Baltimore, 1928, pp. 323.
[36] C. L. Hull, *Aptitude Testing,* 1928, pp. 487–490.

individual.[37] This program, although oriented from the viewpoint of guidance, applies equally well to the problem of selection and implies a description of the requirements of occupations, and perhaps ultimately of single jobs, in terms of weighted scores on the universal battery of tests.

The use of test scores in indicating qualifications for jobs has much to recommend it. The analogy which Link makes with the chemical formula seems pertinent, in the sense that there is a resemblance between the combined constituent traits and responses which make up the complete job and the single elements which, when mixed, create a new chemical product with none of the specific qualities of the individual elements. However, at the present time, there are few jobs for which adequate batteries have been developed and in the case of which an objective statement of requirements in terms of test scores can be made. For this reason a systematic subjective analysis and statement of qualifications for the job remain as probably the most useful procedures in job analysis. Moreover, the preparation of tests requires a thorough-going preliminary analysis, in subjective terms, of the traits to be measured as a means of shortening the process of test development and as an aid in arriving at the extended program of analysis and measurement by test envisaged, for instance, in Hull's proposal.

Job Analysis by Activity

Both the subjective and the test methods of job analysis have been criticized because they employ items not subject to direct observation or to direct measurement. So, for example, Kitson describes the subjective method as "the most precarious tool of vocational analysis, for at best it represents only what some one thinks about the components of the vocation. It has no basis in fact as scientifically demonstrated, and it should be considered as only a second or third best alternative to finding out by experiment what is really required in a vocation." [38] The same author condemns analysis by test because "it really delineates the vocation only in terms of extraneous tests, and not in terms of the vocation itself," [39] and because on the evidence at hand there is no basis for believing that a correlation between performance on the test and performance in the vocation is evidence that the two contain common, identical elements. Out of this criticism grows the recommendation that job analysis be limited to an examination of what the worker actually does in the occupation. This type of analysis calls

[37] C. L. Hull, "An Automatic Machine for Making Multiple Aptitude Forecasts," *J. Ed. Psych.*, 16 (1925), pp. 593–98.
[38] H. D. Kitson, *The Psychology of Vocational Adjustment*, Philadelphia, 1925, p. 63.
[39] *Ibid.*, p. 61.

for an exact statement of the variable operations that the worker performs on the job. Such a statement is detailed in character. It may include, as in the case of Charters and Whitley's [40] analysis of secretarial traits, hundreds of duties which workers in this occupation may be called upon to perform. In the case of single jobs, as in Strong and Uhrbrock's analysis in the printing trade,[41] from 20 to 30 distinct operations may be described. Furthermore, this procedure replaces analysis in terms of "abstract, general, mental traits" and in terms of "tests" with an exact measurement of the output of workers and with the classification of requirements in terms of output levels to be reached by various grades of workers employed at the same job. So, for example, it is suggested that the speed required in linotyping at the upper 10 percentile might be placed at 1000 lines per hour (with no more than 1 error in every 38 lines). In proof-reading the median requirement might be placed at a speed of 900 lines per hour (with no more than 1 error in every 35 lines). Such an approach involves not only a gross observation of activity, but minute measurements of the actual operations involved at work, and direct comparison of good, average, and poor workers as aids in setting up standard qualifications for stated levels on the same job. As an example of minute measurements Kitson cites an investigation of eye movements of proof-readers by means of a moving photographic film in which it was found that a good proof-reader makes, on the average, fewer pauses than a poor one, (7 *vs.* 11), and that the length of the pause is, on the average, shorter for the good reader than for the poor one, (17 *vs.* 19). In addition, the eye movements of the latter tend to be more irregular, that is, less rhythmic in character than that of the good proof-reader.[42]

Time and Motion Study

Job analysis by activity represents essentially a method, early recommended by Taylor, which has been developed into a highly organized system of time and motion study by F. B. and L. M. Gilbreth. "Each job," wrote Taylor, "should be carefully subdivided into its elementary operations, and each of these . . . should receive the most thorough time study." [43] As an aid in making possible instruction in standard methods of work and in establishing wage rates, Taylor divided the job into its elements and studied the time taken on each part by first class men who were induced to work as quickly as possible by the payment of increased wages. *Time study* was soon supplemented by *motion*

[40] W. W. Charters and I. B. Whitley, *An Analysis of Secretarial Duties and Traits,* Baltimore, 1924, pp. 186.
[41] E. K. Strong, Jr. and R. S. Uhrbrock, *Job Analysis and the Curriculum,* Baltimore, 1923, pp. 146.
[42] H. D. Kitson, *op. cit.*, p. 69.
[43] F. W. Taylor, *Shop Management,* New York, 1911, p. 83.

study,[44] or the analysis of the nature of movements constituting the task to make possible its performance in the minimum time with the least waste of effort. Pioneering work in this field was done by F. B. Gilbreth,[45] who both coined the phrase "motion study" and first developed procedures for "dividing the activity into its smallest units, measuring the variables of those units, studying this data, and deducing methods by which the activity may express itself more efficiently." Motion study, "although implying time study, in the sense that the time the motion occupies is one test of the efficiency of the motion," [46] seeks particularly to eliminate unnecessary movements and to improve the necessary ones. In practice time and motion studies are usually closely interwoven as two aspects of a single analysis of methods of work.

Gilbreth first applied only ordinary observation and the stop watch in noting the form and time of movement. However, in the course of time recording techniques have been refined, leading to *micromotion study,* involving methods of recording minute movements and their surrounding conditions by means of a cinematograph and high speed clocks registering extremely small intervals of time. One development took the form of attaching small electric lights to the hands or other members of the body, and to parts of the machine involved in a task. By exposing a photographic film or plate while the worker is in motion there is obtained a continuous white tracing of the path of movement, known as a *cyclegraph.* By using a stereoscopic camera it is possible to procure a three dimensional record of movement, known as a *stereocyclegraph.* In order to determine the time and speed of each part of the movement an accurately timed, pulsating interrupter was introduced into the circuit, with the result that a *chronocyclegraph* was produced, showing a series of dashes instead of a continuous white line. This makes possible a determination of exact time, speeds, relative times and speeds of movement, etc. In this case again a stereoscopic camera can be employed for producing *stereochronocyclegraphs* or three dimensional photographic views of timed movements.

Further refinements in recording the time and nature of movements have included the control of current in such a way that each dash starts as a broad band, gradually narrowing in width so as to form a sort of arrow head showing the *direction* of movement. In addition, by means of *penetrating screens* it is possible to measure directly the length of movements on any plane by reference to a cross-sectioned background forming part of the finished film. Finally, the technique has been completed by the use, in the cinematographic work, of a *microchronometer* showing correct time to 1/2000 second.

[44] E. Farmer, "Time and Motion Study," Ind. Fat. Res. Board *Report,* No. 14 (1923), p. 6.

[45] F. B. Gilbreth, *Motion Study,* New York, 1911, pp. 116, and F. B. and L. M. Gilbreth, *Applied Motion Study,* New York, 1917.

[46] F. B. and L. M. Gilbreth, *Fatigue Study,* New York, 1916, p. 118.

Detailed observations of movements made by these techniques can be objectively shown in the form of wire *motion models* constructed by duplicating with wire the paths as shown in the stereochronocyclegraphs. Such wire models, when completed, are placed in a black box cross sectioned in white to permit measurement in the same way as does the penetrating screen.

These various types of motion studies supplement each other. They all have a common purpose, that of making an intensive study of the elementary motions in work, of eliminating the unnecessary movements, and of combining the remaining efficient movements into a standard method of work—the *one best way* of work [47]—requiring a certain set combination of motions.

The most effective combination of movements is determined on the basis of an intensive job analysis which involves the preparation of a *process chart* on which is recorded, in order of sequence, every movement made by the worker, observed by means of the instruments described above. These movements are analyzed into *therbligs*,[48] shown in Figure 16, defined as the basic elements of motion in industrial processes. With each therblig is associated a symbol and a standardized cross-hatching of color to facilitate the preparation of charts. By entering therbligs on a chart showing the elements of motion and their times vertically, and the parts of the body involved horizontally, there is produced a simultaneous motion-cycle chart or *simo-chart* showing graphically the body parts involved in an operation, the motions made by each, and the relative and actual time consumed by each element of motion. A portion of such a chart, taken from a recent study of skill by Fairchild, is shown in Figure 17.[49]

There is no question that this type of job analysis can be extremely helpful and is perhaps essential in setting up standard methods of work and in establishing wage rates.[50] However, as far as selection is concerned, it is in *itself* of no value because it fails to give any clue to the abilities and aptitudes which underlie the operation and the capacity of the worker to develop skill in its performance.[51] Kitson has clearly foreseen this criticism in his statement that "the objection may be made to this demand for analysis of the occupation in terms of itself . . . that one cannot tell whether a candidate for an occupation possesses the capacities necessary for success in the occupation; for of course, if the oc-

[47] See Chapter XX, page 434.

[48] See Chapter XX, pages 433–37.

[49] M. Fairchild, "Skill and Specialization," *Pers. Jour.*, 9 (1930), p. 43. This chart, it must be noted, differs from the usual simo-chart in a number of respects. The therbligs do not show exact times, but are of uniform and arbitrary length. In addition, the chart includes a record of skill factors, charted alongside the motion or therblig to which they belong. This notation of skill factors is in accordance with an analysis of skill made by Fairchild described on pages 160-63. The chart shown on page 160 is actually a *simo-skill chart*.

[50] See Chapter XX.

[51] E. Claparède, *L'Orientation professionelle,* Geneva, 1922, p. 26.

cupation is described only in terms of its own operations, there are many of these operations which the candidate has not had time or opportunity to acquire, and so the analysis would not be helpful in selecting him or in guiding him." [52] This criticism, so well stated but subsequently neglected by Kitson, describes exactly the chief weakness of job analy-

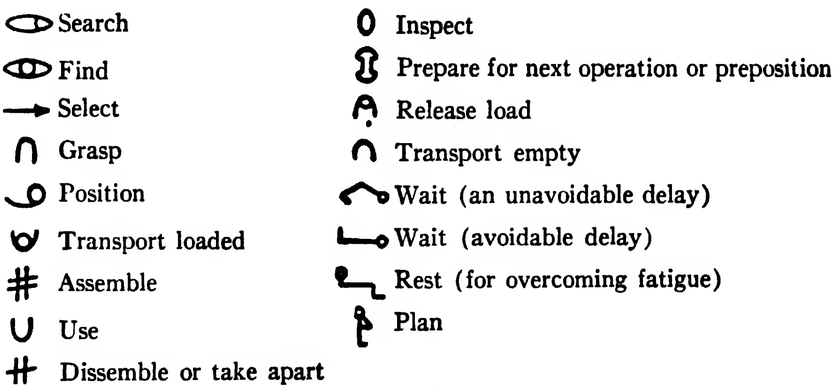


FIGURE 16. *Gilbreth's System of Therblig Notation (After Fairchild)*

sis by activity. At the same time, this procedure can be made the basis of a more intensive analysis of underlying factors by means of psychological techniques. A psychological analysis of those activities in which significant differences exist between superior and inferior workers with respect to time and the movements involved may be of distinct value in the analysis of aptitude requirements, and in the choice of tests for the measurement of these aptitudes.[53] An example of such an analysis is reported by Book,[54] who tested the speed of voluntary tapping with a telegraph key in comparison with the speed of typing of a number of world's champion typists, state and district champions, and a group of students of typing in the School of Commerce and Finance of Indiana University. Rates of finger, hand, forearm, and upper arm movement were measured. The most proficient typists proved to be superior to others in voluntary motor control, particularly of the elbow and shoulder movements and of the left hand and arm. As Hull points out, such an "investigation indicates rather definitely that the power of making rapid repeated movements with the hands and arms is intimately related to typing aptitude" and suggests that "a test

[52] H. D. Kitson, *op. cit.*, p. 66.
[53] C. L. Hull, *op. cit.*, p. 289.
[54] W. F. Book, "Voluntary Motor Ability of the World's Champion Typists," *J. App. Psych.*, 8 (1924), pp. 283–308.

somewhat like the typing test used by Book would very probably be a useful unit in a battery of tests designed to forecast typing aptitude."[55]

The Analysis of Skill

The use of time and motion study techniques as a basis for a further analysis of operations in terms of underlying psychological factors is

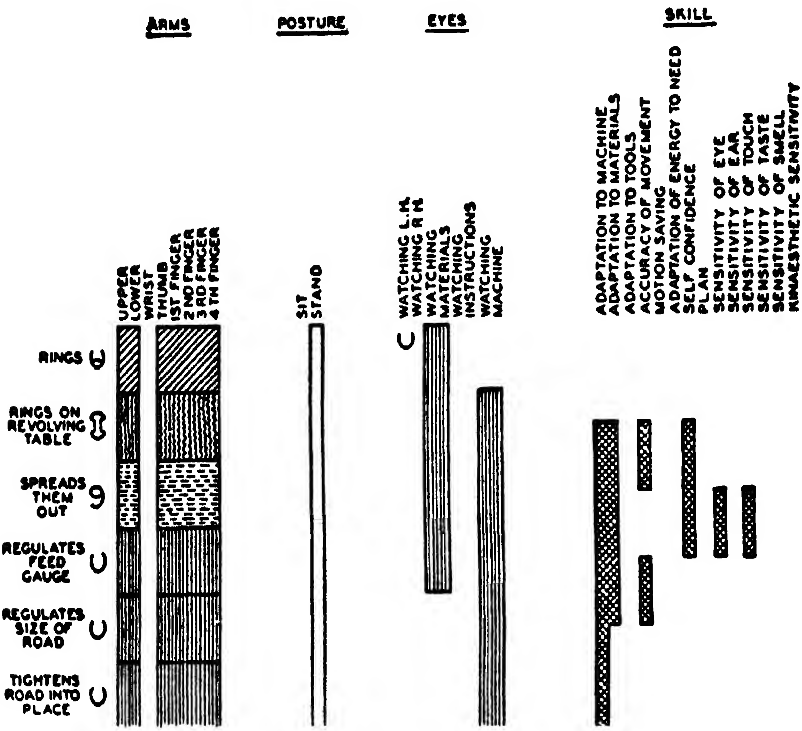


FIGURE 17. *Simultaneous Motion-cycle and Skill Chart*
Machine: *Blanchard Automatic.* Part: *Outer Race Ball Bearing.* Operation: *Surface Grinding*

(*After Fairchild*)

illustrated in a recent investigation by Fairchild of skill and specialization in the metal trades.[56] For the purpose of this study the investigator accepted Pear's definition of skill *as the integration of well adjusted performances adapted under varying situations to the at-*

[55] C. L. Hull, *op. cit.*, p. 292.
[56] M. Fairchild, *op. cit.*, pp. 28–71; 128–183.

tainment of a desired result.[57] The study started with an analysis into therbligs, by Gilbreth motion study techniques, of the operations of 75 "good average" workmen employed upon 11 types of machines in 4 plants. The machines included the punch press, drill press, grinder, planer, milling machine, engraving machine, grooving machine, horizontal boring mill, hand-screw machine, and engine and turret lathes, used in cutting, boring, turning, grinding, and similar operations.

Process charts of all selected jobs were made by the investigators. These were in turn analyzed into simo-charts, in which the unit of

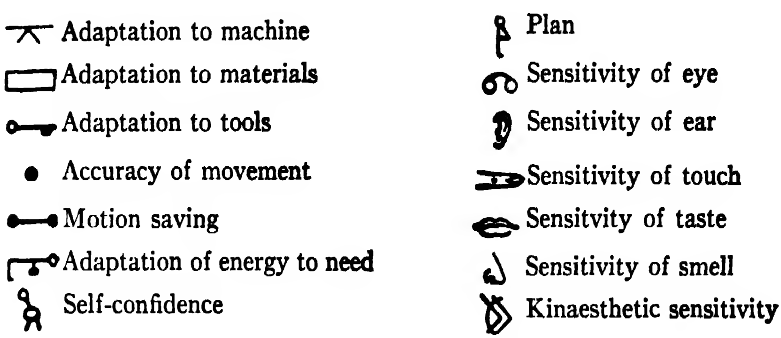


FIGURE 18. *Symbols for Skill Notation*

(*After Fairchild*)

measurement was a therblig of uniform and arbitrary length. For the further analysis of these into terms of underlying skill there was prepared a method of skill notation in terms of standard *skill-factors,* whereby, according to the investigator, "the various aspects of a workman's skill may be observed and isolated." [58] The system of notation of these skill-factors is shown in Figure 18. The next step in this analysis took the form of the preparation of a *simultaneous motion-cycle and skill chart* or the *simo-skill-chart,* consisting essentially of the Gilbreth simo-chart supplemented by a skill notation. On this chart each skill-factor observable in a workman performing a selected job is charted alongside of the motion or therblig to which it belongs. In this way skill-factors are graphically related to the elements of the operation in which they appear (Figure 17). This simo-skill-chart, therefore, represents a picture of the sequence of the operations and of the skill shown by each worker in the performance of every operation.

When the chart is completed a *therblig-skill-average* is obtained for each worker by dividing the total number of skill-factors by the total

number of therbligs charted.[59] The ratio of the therblig-skill-average of each worker to a norm-therblig-skill-average of the group of workmen to which his work is comparable gives a *skill-index,* indicating the skill of the workman in relation to his job.[60] By relating the therblig-skill-averages to a common base, three indexes were established: (1) an index relating the workman's therblig-skill-average to the average of all the men on similar machines; [61] (2) an index relating the workman's therblig-skill-average to the average for all the men in the shop; [62] and (3) an index relating the workman's therblig-skill-average to the average for all the men included in the study in the 4 plants.[63] An analysis of the figures obtained through the application of these formulae (Table 15) shows that the therblig-skill-averages of the workmen tend to increase, with few exceptions, from those used on the punch press, through drill press, grinders, planer, milling machine, engraving machine, grooving machine, horizontal boring mill, hand-screw machine and lathes.[64] This progression gives an indication of the relative complexity of skill involved in operations on these machines. It is interesting to note that the order is close to the accepted grading of the machines by industrialists. The skill indexes provide a means of comparing workmen operating complex machines with those operating simple ones; of studying variations in skill from plant to plant not only with respect to operations, but in relation to training

[59] *Ibid.,* pp. 47–48.

[60] The formula for the skill-index reads:

$$\text{S.I.} = \frac{S}{T} \div \frac{\Sigma S}{\Sigma T}$$

where S.I. = skill index;
S = units of skill on one job;
T = therbligs on one job;
Σ S = total units of skill in all operations under comparison;
Σ T = total therbligs appearing in these operations.

[61] Formula 1:

$$\text{S.I.}_1 = \frac{S}{T} \div \frac{\Sigma S_1}{\Sigma T_1} = \frac{S \times \Sigma T_1}{T \times \Sigma S_1}$$

where S = the total number of skill factors appearing in any one job performed by any one man;
T = the total number of therbligs in the same job;
ΣS_1 = the total number of skill-factor units appearing in all the jobs performed by men doing similar work; and
ΣT_1 = the total number of therbligs in the same jobs.
(The subscript 1 refers to work on the same machines within the same shop.)

[62] Formula 2:

$$\text{S.I.}_2 = \frac{S}{T} \div \frac{\Sigma S_2}{\Sigma T_2} = \frac{S \times \Sigma T_2}{T \times \Sigma S_2}$$

(The subscript 2 designates all selected work within the shop.)

[63] Formula 3:

$$\text{S.I.}_3 = \frac{S}{T} \div \frac{\Sigma S_1}{\Sigma T_1} = \frac{S \times \Sigma T_3}{T \times \Sigma S_3}$$

(The subscript 3 designates all work studied.)

[64] M. Fairchild, *op. cit.,* p. 50.

methods, satisfaction derived from work,[65] wages, and other important variables.

Although the technique employed by Fairchild may be criticized because of its subjectiveness, by reason of the arbitrary analysis into

TABLE 15

Therblig-skill-averages and skill-indexes of selected workmen in the four plants

NUMBER IN FACTORY	WORKMAN SERIAL	MACHINE	MACHINE SERIAL	THERBLIG-SKILL-AVERAGE	SKILL INDEX PROCESS BASE	SKILL INDEX FACTORY BASE	SKILL INDEX INTER-FACTORY BASE
			PLANT A				
1	10	Grinder	VI d	0.79	74	32	22
2	8	Grinder	VI c	1.11	61	51	35
3	12	Grinder	VI d	1.30	121	59	41
4	5	Grinder	VI b	1.42	64	67	46
5	9	Grinder	VI d	1.66	156	76	52
6	26	Punch press	XII	1.75	96	80	55
7	28	Punch press	XII	1.83	111	84	58
8	27	Punch press	XII	1.87	102	85	59
9	6	Grinder	VI c	1.93	107	89	61
10	17	Engine lathe	IX a	2.00	86	91	63
11	20	Engine lathe	IX a	2.30	99	105	72
12	18	Engine lathe	IX a	2.36	101	107	74
13	19	Engine lathe	IX a	2.35	101	107	74
14	7	Grinder	VI a	2.25	129	107	74
15	22	Turret lathe	IX b	2.18	96	113	78
16	25	Turret lathe	IX b	2.54	98	116	80
17	3	Grinder	VI b	2.57	111	116	80
18	13	Groover	VII	2.60	93	119	82
19	4	Grinder	VI b	2.65	114	120	83
20	24	Turret lathe	IX b	2.68	104	123	85
21	21	Engine lathe	IX a	2.90	124	131	90
22	14	Groover	VII	2.88	103	132	91
23	15	Groover	VII	2.94	105	134	92
Mean				2.19		97.6	67.2
S.D.						26.9	18.5
Median						107	74
L.Q.						80	55
U.Q.						119	82
Q.D.						19.5	13.5

(After Fairchild)

skill-factors, etc., it represents an extremely suggestive approach not only for the evaluation of skill, but as a basis for the still further analysis of the underlying capacities necessary for the development of skill. The investigator has carefully refrained from taking this additional step and makes clear that the "study made no attempt to dis-

[65] See Chapter XXV.

cover or to grade either general or specific inherent capacities." [66] At the same time her conclusion, which agrees with that of Pear [67] and of Book,[68] that kinaesthetic and sense knowledge form the basis of adjustment and adaptability through skill suggests the next step to be taken if this type of analysis is to be useful for selection purposes.

The Gestalt Viewpoint in Job Analysis

Under the influence of the *gestalt* [69], or *configurational,* school in psychology there has recently developed a tendency to criticize adversely all methods of job analysis which involve a division of the job into constituent parts. In the latter type of analysis it is assumed, for example, that mechanical ability or aptitude as displayed in press machine feeding is identical in every respect with that displayed in pattern making, and represents a factor common either to all or to many manipulative jobs.[70] The difference between such jobs lies in the number and kind of other abilities or traits or responses associated with it, but mechanical ability underlying manipulation of any kind can be isolated as a stable and unchangeable factor in the manipulative situation. So, for example, in Fairchild's study, the comparison of the workman's skill rests on the assumption that the relation between the same skill-factors used on the different machines included in the study is primarily a quantitative relation. That is, "the nature of the skill-factor utilized to operate one machine would be comparable to that used to operate another." [71]

The emphasis in the gestalt point of view is upon the functional relationship among the diverse work operations and among the underlying mental qualifications rather than upon isolated elements. Stern,[72] for example, distinguishes between the *mosaic* and *structural* principles in job analysis and insists upon the latter, in which the occupation is viewed as a "whole," as a necessary procedure in determining occupational qualifications. Lipmann [73] has also objected to detailed analysis of occupations into psychological elements, on the ground that as an analysis increases in detail, there is a growing inability to isolate functions characteristic of the job. As Baumgarten has pointed out, "each occupation has a characteristic structure. In the analytic type of occupational analysis this structure, that is, the specific pattern of single functions, is destroyed." [74]

[66] M. Fairchild, *op. cit.,* p. 36.
[67] T. Pear, *op. cit.*
[68] W. F. Book, *Psychology of Skill,* New York, 1925, pp. 257.
[69] W. Koehler, *Gestalt Psychology,* New York, 1928, pp. 403.
[70] M. S. Viteles, "Die 'Gestalt' Betrachtungsweise in der angewandten Psychologie," *Z. ang. Psych.,* 35 (1930), pp. 525–31.
[71] M. Fairchild, *op. cit.,* p. 48.
[72] W. Stern, "Persönlichkeitsforschung und Testmethode," *Jahrbuch der Characterologie,* 6 (1929).
[73] O. Lipmann, "Psychologische Analyse der Arbeit," in *Atti della 3. Conferenze Internationale di Psicotecnica Applicata all' orientamento professionale,* Milano, 1923, p. 42.
[74] F. Baumgarten, *op. cit.,* p. 134.

The application of the "structural" principle or gestalt viewpoint in occupational analysis insists upon the maintenance of the structural whole. It leads naturally to an emphasis upon the analogous, as contrasted with the analytic type of test, in the selection of workers for occupations. This is discussed in great detail in Chapter XII. However, as in the development of the analogous test, the analysis by "wholes" is beset with methodological difficulties which have yet to be overcome if this procedure is to attain the importance which it deserves in the study of occupational activities and requirements.

JOB CLASSIFICATION AND GRADING

Closely allied to job analysis and, to some extent, built upon it are the procedures of job grading and classification. These involve a comparison of occupations or vocations as a means of determining relative responsibilities and relationships with respect to operations and underlying skills, capacities, and other traits. When used within the organization, job grading and classification are employed most frequently as a basis for wage schedules—in establishing "a fair return to the individual for his part in concerted production as an essential condition to his co-operative interest in it." [75] The procedures are also useful in setting up lines of transfer and promotion, in indicating the general diversity of requirements in the industrial plant and in otherwise promoting the objective of fitting the worker to the job.

Representative of an early attempt at a psychological classification of occupations (in distinction to the analysis of the single job) is that of Piorkowski,[76] who groups occupations with respect to the amount of general intelligence and number and character of specific abilities required in the work. This classification includes:

1. *Unskilled occupations* in which a minimum of general intelligence and no special abilities are required for success.

2. Occupations involving *special abilities*. These are further subdivided into

(a) *Specialized occupations* involving a limited number of simple psychophysical traits such as attention, motor response, etc., combined with resistance to fatigue and involving a very low level of general intelligence. Many simple machine feeding operations and other repetitive jobs in industry would be included in this group.

(b) *Middle occupations* involving a certain amount of general intelligence and a number of specialized abilities limited in character and combined into a mechanized reaction pattern, including, for example, such jobs as telephone operator, conductor, printer, etc.

[75] J. O. Hopwood, "Fundamentals in Salary and Wage Administration," Amer. Mgt. Assoc., *Office Mgt. Series 55*, 1930, p. 3.

[76] C. Piorkowski, "Beiträge zur psychologischen methodologie der wirtschaftlichen Berufseignung, Beihefte," *Z. ang. Psych.*, 11 (1915), pp. 15–16.

(c) *Higher vocations* involving such higher mental traits as decision, organization, initiative, judgment, and above all, a capacity to distinguish the essential from the non-essential. Such vocations are characterized by a relative absence of mechanization of response. Intellectual traits are of particular importance. Medical, dental, and other professions, as well as semi-professional occupations, would be included in this group.

Lipmann [77] has proposed a classification of occupations with respect to:

(1) the type of mental activity involved, including *gnostic* (that involved in the acquisition of knowledge), *technical*, and *artistic;*

(2) the object upon which activity is centered, viz., *people, things, ideas.*

A somewhat similar classification has been employed by Toops [78] as a basis for the development of tests for purposes of guidance.

In a number of cases general intelligence alone has been applied as a criterion in classifying occupations. This type of grading is well represented in the analysis of the Army test results discussed on pages 121–22, leading to a classification of occupations into a hierarchy of 4 levels with respect to median intelligence test score. The highest level, termed the *professional* level, is subdivided into two parts, including (a) those groups having very high educational and professional standards (Median Intelligence Rating A), and (b) groups having slightly lower educational and professional standards (Median Intelligence Rating B). The next lower level includes clerical workers, technical workers, and probably those skilled mechanics and skilled operatives who, because of high average intelligence and leadership, become foremen (Median Intelligence Ratings C +). In the next lower level there is a larger number of occupational groups than in any other, the majority falling under the heading of skilled mechanics, skilled operatives, and semi-skilled workers (Median Intelligence Rating C). The lowest level contains those occupational groups that may be characterized as unskilled labor (Median Intelligence Rating C —).[79] Similar classifications have been suggested by Fryer,[80] Scott and Clothier,[81] Burt,[82] Awaji,[83] and others.

Job classification is chiefly valuable

(a) when undertaken to meet the needs of the individual organiza-

[77] O. Lipmann, "Psychologie der Berufe," in *Handbuch der Vergleichenden Psychologie,* (Edited by G. Kafka), Munich, 1922, Vol. II, p. 478 ff.

[78] H. A. Toops, *Tests for Vocational Guidance of Children Thirteen to Sixteen,* New York, 1923, pp. 159.

[79] *Memoirs National Academy of Sciences,* Washington, 15 (1921), p. 832.

[80] D. Fryer, *op. cit.*

[81] W. D. Scott and R. Clothier, *Personnel Management,* Chicago, 1923, pp. 643.

[82] C. Burt, "The Principles of Vocational Guidance," *Brit. J. Psych.,* 14 (1923), pp. 336–352.

[83] Y. Awaji, "Intelligenzprüfung im Japanischen Heere," *Z. ang. Psych.,* 30 (1928), pp 81–118.

TABLE 1-6

Co-ordination of service grades and rate ranges. Plan of differentiation in division of labor in industrial enterprises

SERVICE GRADES		FUNCTIONAL CLASSES: Accounting	Boiler Operating	Clerical Service	Designing	General Administration	Machine Construction	Selling	RATE RANGES: Monthly Basis	MINIMUM INTELLIGENCE GRADES
I. MANAGEMENT: 1. General Management	A					President			$2,500–4,500	A
	B					Vice President			1,700–2,800	A
	C					Gen'l Mgr			1,250–1,850	A
2. Departmental and Associate Management	A	Comptroller							$975–1 350	B
	B								750–1,025	B
	C	Gen'l Auditor							600– 800	B
	D				Mechanical Engr.			Sales Mgr.	475– 635	B
	E	Auditor				Executive Asst.	Plant Supt.		375– 500	B
II. OPERATING PRACTICE: 3 Supv. or Highly Tech. Service	A	Sr. Accountant			Chief Designer			Jobbing Salesman	$300– 400	B
	B	Accountant			Senior Designer		Machinist Foreman		240– 325	C+
4. Highly Skilled or Minor Supervision	A	Jr. Accountant	Boiler Engr	Chief Clerk	Designer		Machinist 1st Cl.		$190– 265	C+
	B	Bookkeeper	Asst Boiler Engr	Senior Clerk	Asst. Designer		Machinist 2d Cl.	Salesman in Sales Room	150– 210	C
5 Skilled Service		Asst. Bookkeeper	Boiler Operator	Clerk A	Junior Designer		Bench Hand		$115– 165	C
6. Semi-Skilled Service			Stoker Operator	Clerk B	Draftsman		Machinist Helper		$85– 130	C–
7. Slightly Skilled Service			Ashman	Asst. Clerk	Tracer		Laborer		$60– 100	D
8. Primary Service				Junior Clerk	Junior Tracer		Shop Boy		$40– 75	D–

* Titles, placements and rate ranges are illustrative only.

(After Hopwood)

tion and used as an aid in establishing *its* wage-rates, lines of promotion and responsibility, etc.;

(b) when prepared, for such use, with due regard for the multiplicity of factors affecting the value of the individual to the organization.

The work of Hopwood,[84] of the Philadelphia Electric Company, represents an outstanding example of the application of such criteria in job grading and classification. Hopwood starts with the viewpoint that all service within the organization is productive, and that salaries and wages should be so co-ordinated that work of equivalent scope and merit will return equivalent incomes to the individuals involved. Jobs are then graded with respect to skill required, observation and learning involved, responsibility, etc., into *primary service, slightly skilled service, semi-skilled service, skilled service, highly skilled service* or *minor supervision, major supervision,* or *highly technical service* (included under the general heading of *Operating Practice*), *departmental and associate management,* and *general management* (under the heading of *Management*). In addition to grading by service, i.e., with respect to *scope of activity,* labor within the organization is classified functionally with respect to *kind of function,* e.g., accounting, boiler operating, selling, etc.

The nature of such a classification, which makes it possible to establish equivalent rates for the same grade of service in different divisions, as well as to promote horizontal transfers among divisions, is shown in Table 16. The theory underlying this approach in grading and classification is that the general intelligence of the individual limits his attainment as to grade, while other specific traits determine his fitness for work in particular functional classes. The parallelism between service grades and general intelligence levels is indicated in the Army test ratings shown in the last column of Table 16.

The value of job grading and classification procedures lies not only in the standardization of organization practices, but in setting up objective criteria in dealing with problems of payment, transfer, and promotion in the case of the single worker. As Hopwood has pointed out,[85] it makes it possible to deal equitably with the *individual.* It enables the employment manager and supervisor to appraise the individual's work, in comparison with that of others, with respect to kind and status or grade, and to assign him a rate which he deserves by reason of the status of his work in the organization.

[84] J. O. Hopwood, *op. cit.* (See also M. R. Lott, *Wage Scales and Job Evaluation,* New York, 1926, pp. 161.)

[85] J. O. Hopwood, *op. cit.*, p. 9.

X. THE INTERVIEW AND ALLIED TECHNIQUES

The selection of qualified workers represents the central problem in promoting individual efficiency and adjustment at work. The Personnel Department, endowed with this responsibility, has developed a number of specialized techniques for accomplishing this objective. Chief among these is the *interview*—a "face to face conference" between the applicant and an employment officer. Supplementing this is the *application blank,* on which the applicant furnishes—in more or less complete detail—information which may be useful in determining his qualifications for the job. Before he is granted the opportunity for an interview, and to fill in the application blank, the applicant is often required to write a *letter of application,* and, for some jobs, to submit a *photograph.* The latter is sometimes used by the employment office merely to gauge the appearance of a candidate for employment but in other instances it becomes the basis for judging "alertness," "honesty," "tact," and other personal qualities of the individual. The search for help in the troublesome problem of fitting workers to jobs has also led to the adoption of various *"character analysis systems,"* or techniques for gauging fitness from an examination of *physical characteristics,* such as the shape of the face, hands, etc., and of certain *physiological signs,* such as handwriting, posture, etc.

In general, these methods have been adopted because they seemed to fit the needs of the situation—without any attempt to evaluate the exact contribution of each. The development of selection procedures on a scientific basis makes necessary such an evaluation: first, *to determine the extent to which each method serves to discriminate between suitable and unsuitable workers,* and secondly, *to provide means of improving the predictive value or forecasting efficiency of those methods which seem to contribute something to adequate selection.* Numerous such studies have been made in the case of each of the techniques mentioned above. Only a few of them can be described in this chapter, but they will serve to indicate the character of such investigations, the results obtained, and the conclusions that have been drawn concerning the serviceability of each method.

I—THE INTERVIEW

The interview represents the most favored technique of the Personnel Department in fitting workers to jobs. There are few instances

in which a man is hired without a personal conference, even when other procedures are employed. As a matter of fact, in the majority of industrial organizations placement is based almost exclusively upon the interview, which most frequently takes the form of a brief and informal discussion of data furnished by the candidate on an application blank. This conference is made the occasion for an appraisal of the individual in the light of the requirements of the job and of his possibilities for development in relation to the varied opportunities available in the industrial plant. Throughout the interview the task is one of diagnosis. "The interviewer looks for symptoms that indicate fitness or unfitness for a job. The information he secures from an applicant helps to fill out the details of a mental picture which he is trying to complete. It is a picture which fits the applicant into the job, or which rules him out of consideration." [1]

Although widely used, the interview is subject to many errors in gauging fitness for work. Unless carefully employed it may give an entirely distorted picture of individual fitness and result in gross injustice to the individual who is rejected and in the selection of generally unsuitable workers for many jobs in the industrial organization. The value of the interview for selection purposes is limited *first,* by certain practical difficulties in its administration, and *secondly,* by sources of error inherent in interviewing techniques as ordinarily employed.

The Time Element in Interviewing

The practical difficulties grow largely out of the limitations in the way of the time that can ordinarily be devoted to the conference with the applicant. Partly because the policy of many firms is not to turn away applicants for employment without a brief interview, and partly because refined judgments can be made only with difficulty in an interview, many applicants must be interviewed before one is hired. This naturally means that little time can be devoted to a single applicant. A report from the Curtis Publishing Company states that 75 applicants were interviewed to fill a single vacancy in the typing force. The same organization interviews from 10 to 50 applicants to obtain 1 stenographer, 20 to 25 to procure a high grade clerk, and 10 to 15 to procure an ordinary clerk.[2]

During 1929 the Kearny Works of the Western Electric Company increased its force from approximately 12,000 to 20,000. To make this increase and to take care of normal turnover approximately 22,000 employees were hired. These were selected from 176,000 applicants. In other words, the ratio between interviewing and hiring was 8 to 1. Approximately 40 per cent of applicants were weeded out in the course of a preliminary interview, lasting only about 1 minute, but even with

[1] W. V. Bingham and B. V. Moore, *How to Interview,* New York, 1931, pp. 75–76.
[2] C. H. Griffitts, *Fundamentals of Vocational Psychology,* New York, 1924, p. 94.

10 interviewers not more than about 5 minutes on an average could be devoted to each of the remaining applicants.[3]

In 1929 approximately 176,000 applicants for employment were interviewed by R. H. Macy & Company of New York.[4] Of these about 13,000, or roughly 1 in 13, were employed. Again the preliminary interview lasted approximately 1 minute, and the second or final interview approximately 5 or 6 minutes. In this case it is interesting to note that by training preliminary interviewers and by increasing the time from approximately 1½ to 3 minutes, it was possible to provide a better sifting of applicants in the preliminary interview, thereby reducing the number chosen for further examination. Those chosen for the second interview received a searching examination lasting from 20 to 25 minutes. By this process, in 1930, in spite of an increase in the total number of applicants, it was possible to reduce to 35,057 the number undergoing searching interviews as a means of hiring 11,380 new employees.

The time difficulty in interviewing is real and should not be underestimated in considering the factors which help make the interview unreliable. At the same time, the fact that the interview must be short makes it all the more necessary to eliminate from it all removable sources of error as a way of increasing its diagnostic value.

Sources of Error in the Interview

The chief sources of error in the interview may be briefly summarized as follows: [5]

1. *Conditioned reactions*. As a result of associations with peculiarities of gait, posture, clothes, expression, the interviewer may develop a tendency to react favorably or unfavorably to these stimuli. So, for example, the formulation of the vague judgment "I rather like him; I should say he is clever, but I don't altogether trust him," [6] may merely result from the fact that the posture or gait of the applicant resembles that of some individual with whom the interviewer has had an unpleasant experience in the matter of cunning or dishonesty. Only too frequently in the interview the final judgment expresses the sentiment

> "I do not like thee, Dr. Fell,
> The reason why I cannot tell;
> But this I know, and know full well,
> I do not like thee, Dr. Fell."

2. *Belief in generalized habit*. Another factor affecting the interview and judgments is the common belief that habits are general rather

[3] W. V. Bingham and B. V. Moore, *op. cit.*, p. 58.
[4] *Ibid.*, pp. 60–62.
[5] Adapted in part from C. H. Griffitts, *op. cit.*, pp. 119–26.
[6] E. H. Magson, "How We Judge Intelligence," *Brit. J. Psych.* Mono. Suppl. No. 9 (1926), p. 3.

than specific. Neatness in clothes is interpreted as a sign that the applicant for a clerical job will show neatness in her work. Frowzy or wind-blown hair may create an impression of general untidiness that leads the interviewer to reject the applicant. Many an applicant for a stenographic position has been refused employment because speech and movement are slow, on the assumption that she will likewise show an absence of speed in taking and transcribing dictation.

3. *Unintentional bias.* Unintentionally, questions may be phrased so as to reveal the bias of the interviewer and to evoke an appropriate answer. This is well illustrated in an investigation by Stuart A. Rice [7] who analyzed the records of interviews by 12 investigators of 2000 homeless men, applicants for lodging, and discovered evidence of a contagious transfer of each investigator's individual bias to the applicants with whom he talked, and a corresponding distortion in their replies to scheduled questions. One of these interviewers was an ardent prohibitionist. He found the downfall of 62 per cent of the applicants to be due chiefly to liquor, while only 7 per cent had been seriously affected by industrial conditions. Another interviewer, a Socialist, found that only 22 per cent owed their plight primarily to liquor, and that 39 per cent had been affected chiefly by industrial causes. Moreover, the prohibitionist reported that 34 per cent of the applicants themselves gave liquor as the cause, and 42.5 per cent industrial conditions; but the Socialist quoted only 11 per cent as blaming liquor and 60 per cent as blaming industrial conditions. Each interviewer was a trained and conscientious investigator, but his personal bias affected his interpretation and report, and even modified the statements made to him by the men he questioned.

Unintentional bias has been described by Woodworth [8] as the "*preconception controlling the interpretation*" of facts. This, as Woodworth has pointed out, is an attitude or "mental set" on the part of the interviewer which controls his perception, report, and interpretation of facts in no small degree. Whether the interviewer will find an inferiority complex, stupidity, or sexual obsession on the part of an applicant or worker will depend partly on his orientation and bias acquired through study and reading.

4. *The failure to define terms employed in the interview* is a fertile source of error in arriving at judgments. This applies not only to the description of traits on which judgments are to be made, but to the standards employed in grading them. Moreover, very frequently, facts or questions are so expressed as to convey different meanings to the interviewer and interviewee.

5. *Nervousness of the subject in the course of the interview* is another factor to be considered. This may be more important in the case

[7] S. A. Rice, "Contagious Bias in the Interview," *Amer. J. Soc.*, 35 (1929), pp. 420–423.

[8] R. S. Woodworth, "Psychological Experience with the Interview," *J. Pers. Res.*, 4 (1925), pp. 164–165.

of the really desirable applicant who, because of long years of service on one job, has had little opportunity to accustom himself to the trial of the interview, than for an individual who, as a result of frequent change of jobs and frequent interviews, has learned how to conduct himself in the course of such a conference.

6. *Mimetic tendencies influence the interview.* There is a general tendency for one individual to express the feeling or emotion which he observes in another. Because of this, the transient mood of both the interviewer and interviewee will markedly affect the results of the interview.

To remove or counterbalance these sources of error requires the experimental study of the interview and interviewing techniques. The objectives of such experimental study are: (1) to determine the influence of each factor upon the interview; (2) to study the actual effectiveness of the interview in selecting men; and (3) to devise means for overcoming the effect of adverse influences as a means of increasing the effectiveness of the interview.

Experimental Studies of the Interview

Experimental studies of the interview have, in general, been designed:

1. To determine its *reliability,* that is, the extent of agreement among judgments made by independent interviewers.

2. To check its *validity*—the predictive value of judgments made in the course of the interview—in other words, the efficiency of such judgments in forecasting the success or failure of applicants for employment.

3. To observe the effect of certain changes introduced into interviewing procedures as a means of increasing their reliability and validity.

Among studies on the reliability of the interview is an early investigation by Hollingworth [9] in which 57 applicants for sales positions were interviewed by 12 experienced salesmanagers responsible for selecting salesmen. Interview procedure was not prescribed, but was left to the dictates of the interviewer. Typical results are shown in Table 17, which gives rank assigned to each of 3 subjects by the 12 interviewers. Applicant A, for example, is rated as No. 12 in fitness

TABLE 17

	1	2	3	4	5	6	7	8	9	10	11	12
A	33	46	6	56	26	32	12	38	23	22	22	9
B	36	50	43	17	51	47	38	20	38	55	39	9
C	53	10	6	21	16	9	20	2	57	28	1	26

[9] H. L. Hollingworth, *Vocational Psychology and Character Analysis,* New York, 1929. pp. 115–119.

by one salesmanager and as No. 46 by another. The differences are even more marked in the case of C, who is rated as No. 1 by one judge and as No. 57 by another.

It is evident that reliability of the interview, as indicated by extent of agreement among individual raters, is extremely low.

Similar results are reported by Scott,[10] who asked 6 salesmanagers to judge the ability of 36 applicants for sales positions. In a later experiment, Scott checked the validity of the interview by requiring 13 executives to rate the sales ability of 12 men. Later he compared the production records of these salesmen with the opinions of the interviewers. The unreliability of the interview is again revealed in marked differences in ratings assigned by individual interviewers. The interview is shown to have low forecasting efficiency, or validity, since the average correlation of estimated ranks in sales with actual production records gives less than 25 per cent better than chance prediction. However, the correlation in the case of one interviewer is as high as 0.87, or a little over 50 per cent better than chance.

An intensive study of the value of estimates made in the course of an interview has been reported by Magson,[11] who was interested in investigating how judgments of intelligence are made in everyday life. The judges were men and women in a variety of occupations, including a publisher, builder, clerk, chemist, teacher, etc., who passed judgments on 149 men students from 2 London Residential Colleges for Teachers. In all 91 judges took part in the work, divided as follows: [12]

		JUDGES
(a)	Estimate of general ability based on an interview	35
(b)	" " " " " shorthand reports of interviews	28
(c)	" " " " " prolonged acquaintance	29
(d)	Estimates of sense of humour based on prolonged acquaintance	25
(e)	" general cheerfulness " " "	25
(f)	" quickness of apprehension " "	25
(g)	" profoundness of apprehension " "	25

Students were divided into 6 approximately equal groups, each judged by 5 to 7 judges who were allotted to each group for each set of estimates. The subjects were given 2 series of 8 intelligence tests and, in certain cases, estimates were obtained from acquaintances as another basis of comparison. The mean intercorrelations between all these measures are shown below:

[10] W. D. Scott, "Selection of Employees by Means of Quantitative Determinations," *Ann. Amer. Acad. Pol. Soc. Sci.*, 65 (1916), pp. 182–193. See also D. A. Laird, *The Psychology of Selecting Men*, New York, 1925, pp. 104–107.

[11] E. H. Magson, *op. cit.*

[12] *Ibid.*, p. 106.

			PROBABLE ERROR
(a)	Interviews and shorthand reports	0.37	0.048
	Interview estimates and tests	0.15	0.054
(b)	Shorthand reports and tests	0.13	0.055
(c)	Interviews and mature estimates	0.22	0.053
(d)	Shorthand reports and estimates	0.17	0.054
(e)	Mature estimates and tests	0.54	0.039
(f)	Interviews and sense of humour	0.13	0.067
(g)	" " cheerfulness	0.16	0.066
(h)	" " quickness	0.13	0.067
(i)	" " profoundness	0.09	0.068
(j)	Mature estimates and sense of humour	0.37	0.058
(k)	" " " cheerfulness	0.18	0.066
(l)	" " " quickness	0.56	0.047
(m)	" " " profoundness	0.89	0.013
(n)	Tests and sense of humour	0.18	0.066
(o)	" " cheerfulness	0.15	0.066
(p)	" " quickness	0.33	0.060
(q)	" " profoundness	0.17	0.066
(r)	Sense of humour and cheerfulness	0.85	0.019
(s)	" " " " quickness	0.73	0.031
(t)	" " " " profoundness	0.41	0.056
(u)	Cheerfulness and quickness	0.62	0.040
(v)	" " profoundness	0.14	0.066
(w)	Profoundness and quickness	0.74	0.030

An analysis of results leads Magson to conclude that "the interviews prove to be practically valueless as a means of measuring general ability, for the pool of the interview estimates gives a very small correlation with both mature estimates and the intelligence tests. Similarly, there is very little correlation between the interviews and the differentiated estimates of sense of humour, cheerfulness, quickness, and profoundness." [13] An analysis of introspections shows that the chief factors on which the interview estimates are based are (1) answers to the questions during the interview, and (2) the manner, facial expression, and personal appearance of the subject.

One of the most comprehensive studies of the interview forms part of an English investigation on vocational guidance.[14] The study included an analysis of character estimates made in the course of an interview by ordinary methods, and by methods roughly described as psychological. It involved also a comparison of the judgments of non-trained observers with the judgments of psychologically trained observers.

In the first step of the study estimates on the character traits of

[13] *Ibid.*, pp. 107–108.

[14] W. Spielman and C. Burt, "The Estimation of Character Qualities in Vocational Guidance," Ind. Fat. Res. Bd., *Report*, No. 33, 1926, pp. 57–72.

32 children were made by 2 competent observers, unacquainted with the children, and by 2 teachers who had had them under their care for some time. The traits included *honesty, conscientiousness, industry, ambition, self-respect, ability to get on with others,* and *good humor.* Taking the traits in order, when the judgments of the two observers are compared with those of the teachers, the correlations are 0.19, 0.27, 0.29, 0.32, 0.42, 0.31, 0.39, with an average of 0.31. In other words, reliability of the judgments is low. The average coefficient for the 2 teachers who knew the children was 0.54, showing somewhat better reliability. The correlation between teachers' judgments and that of observers averages 0.22. In other words, the validity of judgments by strangers is also low.

An analysis of estimates made by the ordinary method showed that the qualities selected for judgment were complex and vague. There was found to be a great deal of disagreement among the teachers and the other observers with respect to meaning of these terms. Moreover, the analysis showed that there was no standard concept of meaning with respect to the value of a given grade in rating these traits.

In setting up the improved, or psychological interview, steps were taken to overcome these weaknesses. The first step was that of selecting and carefully defining (1) *simple* and (2) *complex* qualities. The simple qualities included *submissiveness, fear, assertiveness, sociability, anger, tenderness, cheerfulness, sorrow, sex, disgust, curiosity,* and *impulsiveness.* The secondary group included *self-confidence, energy, quickness, initiative, co-operation with superiors, co-operation with equals, co-operation with inferiors, industry, punctuality,* and *reliability.* Each of these was carefully defined, and a rating scale or method for facilitating the expression of judgment in standard, objective terms was developed. Thirty children were then graded by 2 independent investigators who marked the same group after a short interview.

The correlation of the two independent observers for each trait is as follows: submissiveness .85; fear .75; assertiveness .74; sociability .72; anger .71; tenderness .68; cheerfulness .60; sorrow .56; sex .51; disgust .42; curiosity .37; inquisitiveness .23; with an *average of .60.* For the complex qualities the figures are: self-confidence .77; energy .64; general emotionality .62; quickness .61; initiative .57; industry .54; honesty .52; co-operation with equals .50; co-operation with superiors .55; reliability .36; with a *general average of .55.* The closer agreement between the independent observers in this part of the experiment means that it is far easier to procure consistent, or reliable estimates of character qualities when the qualities are defined and when a standard scale is prescribed for rating these qualities.

A further analysis showed that simple or primary qualities can be estimated with greater reliability than complex. Those qualities which are emotional in character are easier to assess than those not emotional

in character. Of the secondary qualities those which spontaneously emerge in the test performance, such as *quickness, energy,* etc., are the ones which can be most easily and most reliably assessed. Where a quality cannot be directly checked in the course of an interview and where the estimates, therefore, have to be based on indirect inference, such as *co-operation with equals,* etc., the reliability of the judgment is low. Where the qualities to be assessed are moral, such as *honesty,* and where extreme manifestation is anti-social in character, the qualities are generally concealed in the course of the interview.

In another part of the experiment 6 young adults were assessed by (1) psychologically trained acquaintances and (2) psychologically trained observers not acquainted with the subjects. The reliability of the estimates of acquaintances is high, averaging 0.75 for the primary qualities and 0.68 for the secondary. The agreement between non-acquaintances is also *relatively* high, 0.63 and 0.60 respectively. The correlations between the estimates of acquaintances and strangers are + 0.58 for the primary qualities and + 0.46 for the secondary qualities. In other words, the validity of the estimates under these conditions is as high as for most existing tests of temperament and character and of many tests of competency used in the industrial situation. The value of the results are clouded by the small number of cases, but the experiment is of unusual interest from the viewpoint of possible techniques for the improvement of the interview.

A comparison of judgments made in the first 6 interviews with those of the last 6, in the second part of the English study, showed increased agreement among observers with practice (+ 0.52 and +0.69 respectively). The effect of training and practice appears more clearly in a recent study by O'Rourke,[15] who has prepared a form for use in connection with the investigation of applicants for Government service. In this, the possible answers to each of the essential questions used in interviewing are anticipated and printed under respective questions on an interview form. All answers are coded, information that is derogatory being indicated by the letters X, Y, Z, information not derogatory or requiring further consideration, coded A, B, C. Interviewers' judgments are then expressed in terms of this code. The estimates of 3 different interviewers may be placed on the same sheet for purposes of comparison. The same procedure is followed in case of oral examinations, where all types of answers are anticipated and a definite procedure prepared for following up the problems on the basis of each response. According to O'Rourke, two weeks of training makes it possible for examiners to administer such oral examinations. Improvement under training in the use of this method is shown in Figure 19. "On the basis of oral examinations administered by a trained examiner, 30 trainees who witnessed the examinations were required to assign to

[15] L. J. O'Rourke, *A New Emphasis on Federal Personnel Research and Administration,* Washington, 1930, pp. 19–21.

each 'applicant' one of the four possible ratings represented by the narrow columns. The height of each black column indicates the percentage of trainees giving that rating. The first three 'applicants' were rated on the first day of the course, before instructions as to ratings had been given. The progress toward uniformity is indicated by the

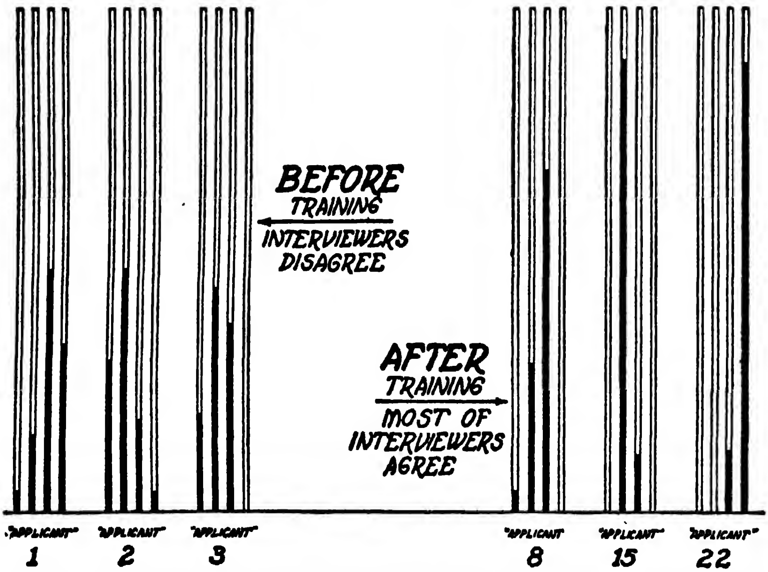


FIGURE 19. *Progress Toward Uniformity in Rating During First Half of Training Course for Examiners*

(*After O'Rourke*)

decreasing diversity in the ratings assigned to each seventh 'applicant' (Nos. 1, 8, 15, 22) during the first week of the training course." [16]

How to Improve the Interview

Experiments such as those described above have suggested that although the interview as ordinarily conducted is unreliable and of low validity, better results can be obtained from the interview by making certain changes in it. Steps to be taken for improving the interview may be briefly summarized as follows: [17]

1. Interviewers should be carefully selected.
2. Interviewers require training in the techniques of conducting the conference so as to make most advantageous use of data obtained in the course of the interview.
3. Traits to be rated in the course of the interview should be care-

[16] *Ibid.*, p. 21.
[17] See W. V. Bingham and B. V. Moore, *op. cit.*, pp. 40–53, and P. M. Symonds, *op. cit.*, pp. 460–474.

fully defined and objective methods for expressing judgments on these traits be provided. The traits chosen for rating will naturally be those required on the particular job and will differ from job to job. Such estimates can best be expressed on carefully prepared rating scales of the type described on pages 206–12.

4. Questions to be asked in the interview must be carefully phrased so as to convey the correct meaning.

5. Interview procedures are in need of standardization. There are varying opinions on the extent to which the interview should be standardized. Certain investigators contend that it should invariably follow a prepared schedule. Some have gone as far as to require that all questions be written out and presented on cards so as to avoid the influence of intonation of voice and facial expression in questioning.[18] A free, untrammelled discussion is recommended by others. An example of a middle course is to be found in the interviewing practices formulated by Anderson in connection with the selection of employees for R. H. Macy and Company of New York.[19]

6. Repeated interviews and comparison of judgments by independent observers help to increase the reliability and validity of the interview.

7. As far as possible the occasion should be provided for objective activities in the course of the interview and for judgments based on the observations of reaction during such performance. Under such conditions the interview may take on the characteristics of a psychological examination in which emphasis is placed upon the quality of performance as well as upon test scores.[20]

II—THE APPLICATION BLANK IN SELECTION

The application blank, generally filled in by the candidate for employment prior to the interview, represents another traditional aid in selection. There are wide variations among such forms with respect to the type of information requested. Some are limited to name, address, age, previous employment; others include a great number of detailed questions on personal history, family history, previous work experience, church and social affiliations, etc. However, although many organizations use such blanks, only a few of them have undertaken to determine the exact value of the blank—more particularly of individual items which appear on it—in determining fitness for work. Investigations undertaken for this purpose have, on the whole, been extremely useful in improving selection by isolating those items in the blank which correlate best with job success. These studies furnish justifications for the conclusion by Kenagy and Yoakum, that "the

[18] S. A. Queen, "Social Interaction in the Interview: An Experiment," *Social Forces*, 6 (1928), pp. 545–558.

[19] V. V. Anderson, "A Psychiatric Guide for Employment," *Pers. J.* 6 (1928), pp. 417–441.

[20] See Chapter XII, pages 247–48.

ideal toward which each company should direct its efforts is an application blank containing all the items which have a definite known significance for success on the job." [21]

Experimental Studies of the Application Blank—Salesmen

The method of application blank analysis has been most successfully applied in the field of selling. At the moment, it is probably more helpful than any other of the techniques which have been tried out for predicting success in this field. Its methods and results are illustrated in an early study by Goldsmith,[22] who applied a scale of "weighted values" to items on personal history (application) blanks of 502 life insurance salesmen. Weights for individual items, shown below, were established in a preliminary study of 34 salesmen and tried out on a second group of 50 sub-divided into 3 groups: *failure, moderately successful, successful,* on the basis of production results of the first year

AGE	
18—20	—2
21—22	—1
23—24	0
25—27	+1
28—29	+2
30—40	+3
41—50	+1
51—60	0
Over 60	—1

EDUCATION	
8 years	+1
10 years	+2
12 years	+3
16 years	+2

MARITAL STATUS	
Married	+1
Single	—1

OCCUPATION	
Social	+1
Unsocial	—1

SERVICE	
Full Time	+2
Part Time	—2

INSURANCE	
Carried	+1
Not Carried	—1

CLUBS	
Belongs to Clubs	+1
Does not Belong	—1

EXPERIENCE	
Previous Life Insurance Experience	+1

CONFIDENCE	
Replies to Question: "What amount of insurance are you confident of placing each month?"	+1
Does not reply	—1

[21] H. S. Kenagy and C. S. Yoakum, *Selection and Training of Salesmen*, New York, 1925, p. 194.

[22] D. B. Goldsmith, "The Use of the Personal History Blank as a Salesmanship Test," *J. App. Psych.*, 6 (1922), 149–55.

of employment. In the case of the 502 salesmen, Goldsmith was able to set a critical score which eliminated 54 per cent of the failures and only 16 per cent of the successful salesmen.

In a study of 4178 agents of 18 life insurance companies Manson [23] finds a correlation of + 0.40 between production records and an application score obtained by combining age at time of application, amount of insurance carried, number of previous jobs and number of dependents. Studies by Swartz,[24] Johnson,[25] and Andrews [26] present further confirmatory evidence of the value of this method in selection. A comparison by the latter of personal history scores and earnings of 73 salesmen shows the possibility of eliminating 70 per cent of the failures without losing a mediocre or successful salesman.

Russell and Cope [27] have studied the application blanks of 500 salesmen selected during the years 1919 to 1921 inclusive by the Phoenix Mutual Life Insurance Company. The treatment of the personal history blank items showed the following twelve to be of value in discriminating between successful and unsuccessful salesmen classified on the basis of earning records: 1. Age, 2. Number of dependents, 3. Marital status, 4. Schooling, 5. Years since leaving school, 6. Selling experience—life insurance, 7. Selling experience—general, 8. Membership in social organizations, 9. Officership in social organizations, 10. Home investments, 11. Number of investments, 12. Insurance carried.

The method employed for computing the score for each item can be illustrated by reference to marital status. The analysis of application data showed that 59 per cent of the men who were married at the time of employment were in the successful group, whereas only 49 per cent of single men were in this group. A score of 59 was therefore allowed to each married applicant and 49 to each single applicant. An analysis of selling experience showed that of men with no selling experience of any kind, 66 per cent were successful, of men with 3 to 6 years' experience, 86 per cent were successful, and of those with over 6 years' experience, 90 per cent were successful. The scores 66, 86, and 90 were therefore assigned to these respective lengths of experience in selling.

When applicants' blanks were scored in this way it was found that of salesmen selected in 1920 none who made composite scores of less than 640 were successful. Of those who made scores above 670, 76 were successful and 27 failures. Of those with scores ranging from 641 to 670, only 24 were successful and 42 were failures. In other

[23] G. E. Manson, "What Can the Application Blank Tell?" *J. Pers. Res.*, 4 (1925), pp. 1–28.

[24] G. O. Swartz, "Selecting Salesmen," *J. Pers. Res.*, 2 (1924), pp. 457–459.

[25] O. R. Johnson, "Basing Selection of Salesmen on Analysis of Company Experience," *Serv. Bull.*, Bur. Pers. Res., 5 (1923), pp. 22.

[26] G. L. Andrews, *A Grading System for Picking Men*, Sales Mgt., 1922, pp. 143–144.

[27] W. Russell and G. V. Cope, "A Method of Rating the History and Achievements of Applicants for Positions," *Public Personnel Studies*, 3 (1925), pp. 202–209.

words, the elimination of those with scores below 640 would apparently bar no successful salesmen. The use of a score above 670 would lead to the inclusion of a small percentage of failures. One out of three with scores between 641 and 670 could be expected to be successful.

According to the authors there has been a marked increase in sales and in the stability of those employed as salesmen as a result of the application of this new method of selection. In 1919, 56 out of each 100 salesmen employed failed to last out the first year. In 1921–1922, when the new plan was fairly operating, only 42 out of each 100 salesmen employed failed to remain one year. Between 1922 and 1925, this figure had been further reduced to 30 out of each 100. This represents a tremendous saving, inasmuch as it costs between $50,000. and $100,000. to select and train 100 salesmen. Moreover, whereas in 1912 the company employed 1700 salesmen to sell insurance to the value of $20,-500,000.; in 1923, under the new plan, 375 salesmen had sold insurance to the value of $52,000,000

Predicting the Earnings of Taxicab Drivers from Application Blanks

The applicability of application blank analysis in predicting sales ability has appeared in the study by the author of taxicab drivers. Although this is not ordinarily realized, one of the chief responsibilities of the cab driver is that of selling transportation. In the Yellow Cab Company of Philadelphia, where this study was made, taxicab operators were actually known as *driver-salesmen* and instruction in merchandizing and sales campaigns were made part of the operating policy of the company by E. S. Higgins, General Manager at the time the study was made.

A preliminary investigation showed that neither a mental alertness test that was being used in hiring driver-salesmen, nor a test for determining accident susceptibility had any value in predicting sales ability as measured by gross income and by earnings on a commission basis. An intensive study was then made of the application blanks of 80 driver-salesmen employed during 1924 and still in the employ of the company in March, 1926. This group included the 40 men with the highest earning record during 1925, and the 40 men with the lowest earning record during the same year—in all, approximately the *best 25 per cent* and *poorest 25 per cent* of salesmen hired in that year.[28]

The technique devised by Russell and Cope [29] was used in analyzing application blank data, and in assigning weights to items which appeared to distinguish between successful and unsuccessful driver-salesmen. These included *age, nationality, marital status, number of children, number of other dependents, trade followed prior to employment by Yellow Cab Company,* and *weight.*

Before applying in selection the total scores obtained by weighting

[28] See Chapter VI, pages 58–60.
[29] See page 181.

these items, the method was checked by scoring the application blanks of all driver-salesmen hired during the first 6 months of 1925—a total of 188 divided into *25 per cent best, 50 per cent average,* and *25 per cent poorest* from the viewpoint of average weekly earnings during 1925. An analysis of application scores showed that if 270 had been used as a critical score in selecting these driver-salesmen, 60 per cent of the *poorest* earners would have been rejected. At the same time, 22 per cent of the *best* earners and 18 per cent of the *average* earners would have been refused employment. Of 53 men who would have been refused employment on the basis of application score, 19 per cent were found to be among the *best* earners, 39 per cent among the *average* earners, and 51 per cent among the *poorest* earners.

Before using this procedure in hiring a study was also made of the earnings during the first 18 weeks of employment of all driver-salesmen, 72 in number, hired from November 22, to December 31, 1926. Although not considered in employment, application scores were computed. Figure 20 shows the average weekly earnings, over a period of 18 weeks, of driver-salesmen with application scores below 270 and with those of 270 and above. The consistent difference in average earnings between the two groups is evident.

The forecasting efficiency of this application score is far from perfect. However, figures are available to show the superiority of this method over traditional standards employed in hiring driver-salesmen. Following a change in management of the Yellow Cab Company the application score was discarded and the following traditional criteria in employment were substituted:

Age—23 to 35 years
Weight—Minimum of 126 pounds
Height—66 inches.[30]

Table 18 shows the percentage of *best, average,* and *poorest* earners rejected by these traditional standards in comparison with those rejected by the application score. The superiority of the latter is evident.

Application Scores on Other Occupations

Although the application score method has been extensively used in predicting sales proficiency, there is no reason for suspecting that its value is limited to this type of work. The author has found an application score weighting age, marital status, number of children, number of dependents, nationality, and height useful in predicting the stability of electrical substation operators. In a recent study Ford[31] has found

[30] These are the traditional standards of the transportation industry—used particularly in hiring motormen. The new management applied this standard indiscriminately to motormen and cab drivers.

[31] A. Ford, "The Influence of Marital Status on Labor Turnover," *Papers of Michigan Acad. of Sciences,* 10 (1929), pp. 381–388.

that the ages 20 to 24 are the worst possible ones for voluntary turnover among substation operators. Above these years there is a steady

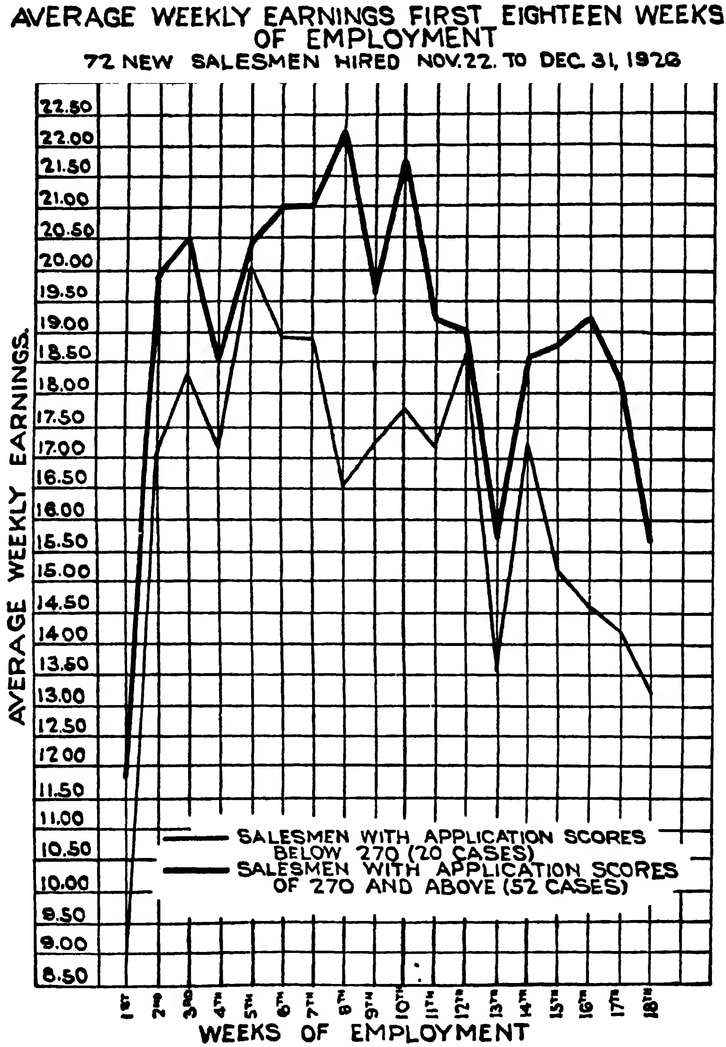


FIGURE 20.

(*From an unpublished study by the Author*)

increase in stability with an optimal period between the years 30 to 34 (at time of employment). In addition, turnover percentage is greater for single men by a nearly constant amount for all lengths of service.

Over one-half of all single men leave the service prior to the end of the 2-year training period, while only one-third of the married men drop out in the same period. It requires 7 years of service to produce as much turnover among married men as would be present in 2 years among single men. In general, although age is important, marital status is about one and one-half times as important in predicting labor turnover among electric substation operators.

Bridgman's study [82] of college graduates in the Bell system shows

TABLE 18

1925 Earners

EARNERS	TOTAL REJECTIONS TRADITIONAL STANDARDS		TOTAL REJECTIONS APPLICATION SCORE OF 270	
	NO.	PER CENT	NO.	PER CENT
45 Best	20	44	10	22
94 Average	36	38	16	18
45 Poorest	16	36	27	60
Total	72	39.1	53	29

that good scholarship, campus achievement, and early graduation, in that order, are significant indices of success. Other factors are undoubtedly important, but the weighting ot such information obtained either directly from the college or on application blank may prove to be a useful method in predicting the success in business of college graduates.

The Letter of Application

Although less frequently employed in selection and, therefore, less important, studies by Walton,[83] and by Poffenberger and Vartanian,[84] have shown that general impressions formed by reading letters of application contribute nothing to the accuracy of selection. It seems probable that the procedure of requesting information that is definitely pertinent to the job, and the weighting of such information, may improve the forecasting efficiency of the letter of application as it has that of the application blank.

III—ESTIMATION OF FITNESS FROM PHOTOGRAPHS

The photograph plays an exceedingly minor rôle in selection for a very large majority of industrial occupations. In the case of technical,

[82] D. S. Bridgman, "Success in College and Business," *Pers. J.*, 9 (1930), pp. 1–19.
[83] H. L. Hollingworth, *op. cit.*, pp. 69–80.
[84] A. T. Poffenberger and V. H. Vartanian, "The Letter of Application in Vocational Selection," *J. App. Psych.*, 6 (1922), pp. 74–80.

semi-professional and professional jobs it is often still requested. Although obtained primarily as a basis for judging appearance, it is also used to estimate "intelligence," "honesty," "neatness," and other personal qualities. Such judgments are generally impressionistic, but occasionally they involve an application, by the employment manager, of one of the systems of character analysis discussed below.

Among investigations on the validity of character judgments from photographs is a study by Anderson,[35] who required 12 graduate students and instructors in psychology to inspect the photographs of 69 executives and sub-executives of a department store and to grade them in "order-of-merit" in general intelligence. The ratings correlated 0.27 ± 0.07 with scores on a general intelligence examination.

McCabe[36] has recently duplicated an earlier study by Cogan in which estimates on "sociability," "likeability," "neatness," "conceit," "humor," "intelligence," "refinement," "beauty," "snobbishness," "vulgarity," based on photographs, were compared with judgments on these traits by close acquaintances. Photographs were taken by the same photographer, all in the same pose and in the same costume. The study included 40 subjects rated by 20 sorority sisters and by 20 strangers. Judgments by both close acquaintances and strangers were found to be reliable. Only in the case of "beauty" was there significant correlation between ratings of associates and strangers ($+0.61$). For intelligence the correlation was ($+0.40$).[37] The remainder, with the exception of one, were below 0.30. The results, as Hull sadly remarks, "certainly look very bad for the judgment of character on the basis of photographs."[38]

Judgments of Photographs by Personnel Workers

For those who still believe in the validity of such judgments, results obtained in an experiment by the author, assisted by K. R. Smith, will be even more disappointing. The objectives of this study were: (1) to investigate the accuracy of judgments on vocational aptitude and success or failure made by experienced personnel workers from an examination of photographs, (2) to determine the degree of certainty with which such judgments are made, (3) to analyze the specific physical and other signs employed when making such judgments, (4) to compare the judgments and degree of certainty of experienced personnel workers with those of observers inexperienced in the selection and management of workers.

[35] L. D. Anderson, "Character Judgments from Photographs," *J. App. Psych.*, 4 (1921), pp. 152–155.

[36] F. E. McCabe, *The Relation Between Character Traits and Judgments, Based on Photographs*, (cited in C. L. Hull, *Aptitude Testing*, Yonkers, N. Y., 1928, pp. 114–119).

[37] It is interesting to note that the correlations of academic grade with ratings in intelligence by acquaintances was $+0.74$. This undoubtedly reflects knowledge of the actual grades made by their friends. In the case of strangers correlation with academic grade was only $+0.11$.

[38] C. L. Hull, *op. cit.*, p. 119.

The procedure employed in this investigation followed that used by Landis and Phelps [80] in a study published in 1928. The only important difference is in the choice of subjects. The subjects of the experiment by Landis and Phelps were college students. In the present study judgments were made by 24 members of a personnel association of a large Eastern city. The majority of these were employment managers or interviewers in industrial plants. A few were employed in placement work in public and private employment agencies. Practically all have had occasion to use photographs in making judgment on personality in connection with employment or placement. Nearly every member of the group was acquainted with one or another physiognomic system of character analysis. Approximately 10 of this group of personnel workers had received formal training in physiognomic systems of character analysis, and 3 or 4 made strict application of such systems in their daily work.

The material employed in the experiment, obtained through the courtesy of Dr. Carney Landis, consisted of photographs of 5 *successful* and 5 *unsuccessful* men in the fields of *law, medicine, education,* and *engineering,* making a total of 20 successful and 20 unsuccessful men. Landis and Phelps describe as follows the method and criteria employed in the selection of the photographs.

"An alumni publication of a large American university was secured. This publication was issued on the 25th anniversary of the graduation of a class of 850 men and it contained an autobiographical sketch of each man together with his photograph at the time of graduation and at his 25th anniversary of graduation. For the purposes of this study, all autobiographies of men who had gone into law, medicine, education and engineering were read and assigned a rating from 1 to 10 on the basis of their apparent worldly success. For instance, a lawyer who had risen to be one of the chief attorneys for the Standard Oil Company was judged relatively successful, while one who was acting as clerk in a large law office was relatively unsuccessful. A man who had taught for 25 years in the common schools was judged relatively unsuccessful, while one who had risen to the superintendency of schools in a large city was judged relatively successful. In this study it must be borne in mind that success or non-success relates only to the vocation and is always a relative term—relative to the performance of other members of his own college class."

Landis and Phelps point out the advantage of this method of selecting photographs for use in an experimental investigation of predicting success or failure from photographs. The selection was made not on the grounds of the *appearance* of *success or failure,* but on the basis of an autobiography which gives a clear picture of how successful each individual has been in the period of 25 years subsequent to graduation from college. In this respect, as Landis and Phelps point out, the

investigation differs from earlier studies, such as those of Gaskill, Fenton, and Porter [40] and of Pintner,[41] Anderson,[42] and others, in which photographs were not selected on the basis of complete factual evidence with respect to the "strength" of the trait under consideration.

In addition to the photograph taken upon the occasion of the 25th anniversary of graduation from the university, use was made of a photograph of each of the 20 "successful" and 20 "unsuccessful" men taken shortly before graduation from college. This made it possible to study the *prediction of success* from the examination of photographs of younger men as well as the *judgment of success* made on the basis of an examination of the photographs of mature men.

The photographs were divided into two groups—one of younger men, and one of older men. The 40 photographs of each group—20 of successful and 20 of unsuccessful men—were scattered in random order with respect to success and with respect to actual vocation. The photographs were projected one at a time upon a screen. Those of "successful" and "unsuccessful" men, taken at the time they were college seniors, were presented first, and immediately afterwards the 40 photographs of the older men were shown. Subjects were told that the photographs of the "younger" men were taken when they were seniors at college some 25 years ago and that those of the older men were taken recently. They were not informed that the two groups of pictures were of the same men. The subjects were told that certain pictures were of men who are (or will be) very successful in their chosen occupations, and that others were of men who are (or will be) relatively unsuccessful. No cue was given to the nature of the occupation involved.

Each subject was given two blanks and instructed to record for each picture, in the case of the "older" group (1) whether the man was relatively successful (S) or relatively unsuccessful (F) in his chosen work; (2) the per cent certainty of this judgment; (3) the occupation in which the man was employed; [43] (4) the basis of judgment, e. g., shape of face, appearance of eyes, facial expression, height of forehead, etc., identified by a code number from a mimeographed list supplied to the rater. For the photographs of the younger group, i. e., photographs taken at the time of graduation, subjects were instructed to record similar judgments in the form of predictions.

Figure 21 shows the percentage of correct judgments of "success" and "failure" of personnel workers in comparison with those of 90 college students who contributed judgments in the original experiment

[40] P. C. Gaskill, N. Fenton and J. P. Porter, "Judging the Intelligence of Boys from Photographs," *J. App. Psych.*, 11 (1927), pp. 394–403.

[41] R. Pintner, "Intelligence as Estimated from Photographs," *Psych. Rev.*, 25 (1918), pp. 266–296.

[42] L. D. Anderson, *op. cit.*

[43] Each subject was supplied with a list of 70 occupations, identified by a code number, classified into 7 groups: law, business, education, intellectual other than teaching, engineering, agriculture, medicine.

by Landis and Phelps. In the case of both groups the accuracy of judgment is no better than chance. Both groups would have done as well tossing coins, recording an "S" for every head, and an "F" for every tail, as they did by deliberately attempting to "read the photographs."

An analysis of the complete data, not presented in this volume, shows

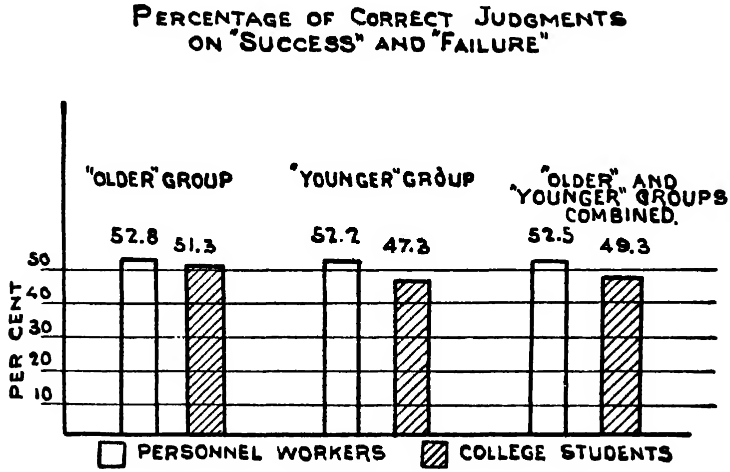


FIGURE 21.

(After Viteles and Smith)

that whereas college students divided their judgments evenly between success and failure, personnel workers tended to make approximately 75 per cent "S" judgments in the case of both the successful and failure groups. In other words, personnel workers are more optimistic concerning the success of their fellow-men than are college students.

The per cent certainty of judgments of the two groups of subjects is shown in Figure 22. It is evident that although personnel workers are just as inaccurate in their judgments as college students, they tend to be approximately one and a half times as certain in the feeling that they are right.

Neither group exhibited any degree of accuracy in selecting the occupations of the men whose photographs were shown. Personnel workers relied upon "general impression" and "facial expression" in the case of 61 per cent of their judgments of "older" men, and in the case of 44 per cent of their predictions regarding the "younger" men. It is significant to note that in few instances were the specific criteria of the character analysis systems employed in arriving at a decision of success and failure.

In summarizing the results of their experiment, Landis and Phelps point out that their study "lends absolutely no evidence toward the

confirmation of the claims of the physiognomists. It offers no evidence which would indicate that the inclusion of a photograph in a letter of application or on a personnel sheet is of any positive value." This earlier experiment was open to the criticism that its subjects were callow, untrained college under-graduates whose experience in judging men was too restricted to permit an adequate judgment, regardless of the criterion employed. The present experiment shows that personnel

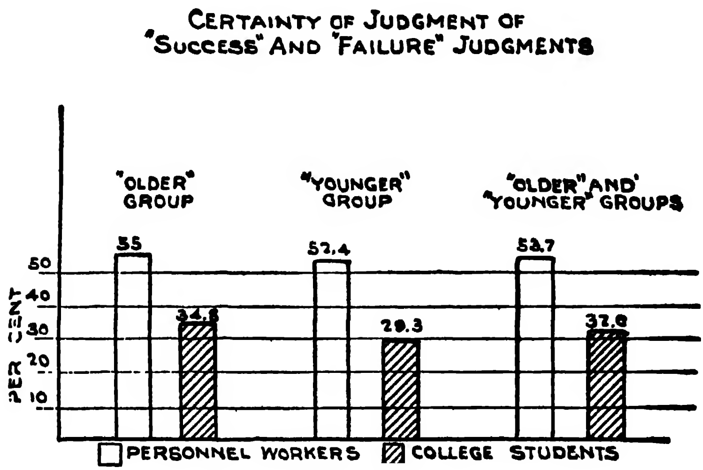


FIGURE 22.

(*After Viteles and Smith*)

workers, in spite of their experience in handling men, can use the photograph to no better advantage than can college students.

IV—CHARACTER ANALYSIS SYSTEMS

The oldest systems for analyzing the personal characteristics of the individual and guiding him into the right kind of work are based on an examination of physical characteristics. The majority of these assume that there is a close relation between the anatomy of the individual and his mental characteristics, and that the character of this relationship may be discovered by a casual examination.

Such systems extend back into the ages. Greek authors prior to Aristotle explained differences in temperament on the basis of variations in the compounds of the 4 elements—earth, air, fire, and water—which were claimed to be the essential constituents of the human body.[44] Hippocrates (460–370 B. C.) denied this explanation and suggested instead that humanity could be easily fitted into 4

[44] G. V. Cleeton, "Estimating Human Character," *Sci. Mo.*, 23 (1926), pp. 427–431.

types; namely, *the sanguine, the choleric* (bilious), *the melancholic,* and *the phlegmatic,* depending upon the relative fluid content of the 4 bodily humors—blood, yellow bile, mucus, and black bile. Inasmuch as the dominance of each gives a characteristic tone to the skin, temperament can be judged by an examination of the individual's appearance. Modified later by Galen, this grouping has become classic and furnishes the basis for modern classifications of character.

The Rise of Phrenology

The first attempt at the development of a commercial system of character analysis was made by the *phrenologists.* Although in 1787 Lavater, a Swiss naturalist, wrote an elaborate dissertation on the topic, the system gained prominence through the work of Franz Joseph Gall, who in about 1800 began giving public lectures on his system of *crainoscopy* or *phrenology.* The assumptions of this system are: (1) Each section of the brain is the seat of a particular mental "power" or "faculty," such as philoprogenitiveness (love of children), cautiousness, secretiveness, benevolence, amativeness, etc.; (2) The degree of prominence of any faculty or personality characteristic depends upon the development of that section of the brain in which it is located; (3) The degree of development of any area can be determined by passing the hand over the skull, since protuberances will be found over well developed areas of the brain; (4) By comparing the location of these "high spots" with standard charts, a complete analysis of individual personality can be made.

This system of character analysis gained wide-spread popularity during the middle of the nineteenth century. It made a real contribution in stimulating the scientific study of brain function, which has clearly demonstrated that there is no localization of "faculties" in the brain. As a matter of fact, the very "mental faculties" on which the system is based have been discarded as psychological artifacts. In spite of this, phrenology still flourishes somewhat in a few quarters and the phrenologist with his trappings of charts and crainoscopic instruments does a thriving trade.

Modern Character Analysis Systems

In general, phrenology has largely been replaced by newer systems in part derived from it and in part from still older anatomical beliefs.[45] In these modern systems little emphasis is placed upon the surface of the skull. The major stress is laid upon physiognomy—that is, the shape of the face, the size and form of chin, nose, etc. Attention is also centered upon color and texture of hair, texture of skin, shape of hand, length of fingers, and so on. In one of the most widely known of these systems an abundance of energy—mental and physical—is

[45] K. Dunlap, "The Reading of Character from External Signs," *Sci. Mo.*, 15 (1922), pp. 153–155.

said to be the most outstanding characteristic of the individual with a pure convex profile (of face). "Superabundance of energy makes the extreme convex keen, alert, quick, eager, aggressive, impatient, positive, and penetrating. The tendencies indicated by his convex mouth will cause him to speak frankly and at times even sharply and fiercely without much regard for tact or diplomacy. . . . The pure concave, as might be expected, is the exact opposite, so far as the indications of form are concerned, of the pure convex. The keynote of his character is *mildness*. . . . He is slow of thought, slow of action, patient in disposition, plodding. . . . The convex is also, in the majority of cases, a blond. The combination of hopeful, optimistic, restless, organizing, creating, domineering characteristics of the blond with the quick, alert, practical, aggressive qualities of the convex make this type distinctly the type of action." [46]

In the same system the blond is described as possessing positive, dynamic, driving, aggressive, domineering, impatient, active, quick, hopeful, speculative, changeable, and variety loving characteristics; whereas the normal brunette is characterized by negative, static, conservative, imitative, submissive, cautious, painstaking, patient, plodding, slow, deliberative, thoughtful, specializing traits. Moreover, delicate skin and a fine texture of hair reveal a refinement not possessed by the individual with coarse hair and rough skin.

In another system conscientiousness is indicated by a broad, bony chin; benevolence by a full, rounded, moist under lip; synthetic ability by the roundness and prominence of the tip of the nose; judgment by a broad large nose; mathematical ability by the squareness of the face bones, width between the eyes, and by an upward curve of the outer part of the eyebrow. In this system certain of these signs may be modified by others. For this reason, the degree of development of a characteristic is read not from a single anatomical sign but from a sort of *physiognomic pattern*. So, for example, the physiognomic pattern that indicates well-developed color-sense is decided by color of the complexion, eyes, eyebrows and hair, clearness of skin, and veins showing through.

The exponents of such systems have been quite successful in the United States. They have been employed by industrial executives to prepare "character readings" of minor executives and of other employees. Many employment managers have attended or subscribed to instruction courses on such character analysis systems, and a few of them are still applying these methods in their daily work of fitting men to jobs. The number is not large. In a survey made in 1922 by Kornhauser and Jackson,[47] questionnaires were sent to 100 employment managers and to 100 insurance agency managers asking their practice

[46] K. Blackford and A. Newcomb, *The Job, the Man, the Boss,* New York, 1914, p. 154.

[47] A. W. Kornhauser and A. W. Jackson, "A Note on the Extent to Which Character Analysis Systems are Used in the Business World," *J. App. Psych.*, 6 (1922), p. 302.

in using character analysis systems. Of 65 replies, 6 admitted using such a system. The number is small, but there is reason for regret that even this number should be willing to make employment and promotion depend upon a scheme that experimental analysis shows to be without any validity.

Experimental Studies of Character Analysis Systems

When submitted to examination under experimental conditions none of the character analysis systems has withstood the test. The methods and results of experimental studies of such character analysis systems are illustrated in an investigation by Paterson and Ludgate.[48] They listed in random order on a rating sheet the 26 characteristics ascribed to blonds and brunettes by Blackford. Ninety-four college students were asked to select from among all the people they knew very well 2 pronounced blonds and 2 pronounced brunettes and to rate them with respect to these characteristics. A plus sign was placed after the name of each to indicate that he possessed the characteristic mentioned and a minus sign to indicate that this characteristic was not possessed. On the average 63 per cent of the blonds and 61 per cent of the brunettes are rated as possessing the so-called blond traits; 40 per cent of the blonds and 42 per cent of the brunettes are rated as having the brunette traits. It is evident that there are no differences between the blonds and brunettes in the percentage rated plus on blond traits, and between the blonds and brunettes on the percentage rated plus on brunette traits. The figures stand in clear contradiction to the claims made by the character analysis system under investigation.

Further evidence of the same kind has been furnished by Kenagy,[49] who asked each of 38 sales executives to rate the 4 best producing salesmen on the same 26 traits. Of the 152 best salesmen 82 were brunettes and only 70 were blonds. Blond and brunette traits were not distributed among these in accord with the proportion claimed by Blackford. "In only three cases do the blonds exceed the brunettes by as much as 5 per cent in the possession of blond traits. In three cases the brunettes actually exceed the blonds. Again, while the brunettes exceed the blonds 5 per cent or more only three times in the possession of brunette traits—the blonds actually exceed the brunettes by 7 per cent or more in three such traits—painstaking, patient, and specializing. The evidence of these figures is unmistakable. It is obvious that these so-called blond and brunette traits do not differentiate between human beings who are commonly classified as blonds and brunettes. Any system of selection or character analysis based on these traits is therefore impractical and unsound."

[48] D. G. Paterson and K. Ludgate, "Blond and Brunette Traits," *J. Pers. Res.*, 1 (1922), pp. 122–127.

[49] H. G. Kenagy, "Do Blonds Make the Best Salesmen?" *Sales Mgt.*, 5 (1923), pp. 523–26.

Other claims put forward by character analysis systems have been experimentally investigated by Cleeton and Knight,[50] employing as subjects 28 college students chosen in about equal numbers from one

TABLE 19

Correlation Between Ratings of Character Factors and Physiognomic Measurements Alleged to be Symptomatic of these Factors

TRAITS	RATINGS OF CLOSE ASSOCIATES AND PHYSICAL MEASURES	RATINGS OF CASUAL OBSERVERS AND PHYSICAL MEASURES	RATINGS OF CLOSE ASSOCIATES AND THOSE OF CASUAL OBSERVERS
Judgment	—.01	.14	.32
Intelligence	.03	.05	.02
Frankness	.05	.15	.21
Friendliness	—.11	.19	.18
Will-power	—.07	.04	.26
Leadership	—.04	.07	.31
Originality	.09	.08	.32
Impulsiveness	.10	—.07	.20

(After Cleeton and Knight)

national fraternity and two sororities. Eight character traits: sound judgment, intellectual capacity, frankness, will-power, ability to make friends, leadership, originality, and impulsiveness, were treated in this investigation. Physical characteristics commonly supposed to be diagnostic of each trait were assembled and submitted to accurate measurement with calipers, tapes, head squares, and other especially designed instruments. In the case of judgment 28 distinct measures were made; 29 for intelligence; 13 for ability to make friends, etc. Ratings by close associates on these character traits were obtained for each member of the three fraternities by asking all other members of the fraternity to supply a rate on each trait. In addition, 70 judges accustomed to handling men were requested to prepare ratings on the same traits by observing the subjects as they sat on the platform of an auditorium. Both the ratings of close associates and those of the casual observers were found to be highly reliable. The results obtained by correlating the physical measures with ratings of close associates and of strangers are shown in Table 19. Almost half of the correlations are negative and the highest correlation is .32, or approximately 5 per cent better than chance. Moreover, no agreement was found among physical factors presumably measuring the same traits. The average correlation of 201 factors studied in this way is zero.

Hull [51] has recently reported an investigation by one of his students,

[50] G. U. Cleeton and F. B. Knight, "Validity of Character Judgments Based on External Criterion," *J. App. Psych.*, 8 (1924), pp. 215–231.
[51] C. L. Hull, *op. cit.*, pp. 127–130.

Evans, designed to determine the character significance of the profile. Twenty-five members of the same university sorority rated each other on optimism, activity, ambition, will-power, domination, popularity, blondness. The reliability of all of these ratings with the exception of popularity, was above .80. Accurate measures were made of the profile by means of special device giving an accurate index of facial convexity. The results obtained are shown in Table 20.

If the claims suggested by the quotation on page 192 are sound, a high correlation between physiognomic traits and the first five of the character traits would result. The table shows no such correlation. Convexity seems unrelated to various character traits with the exception of convexity of the lower face (chin to eyebrows, without nose) which seems to give a consistent series of fairly high positive correlations

TABLE 20

Showing the Correlation Between Various Physiognomic Traits and a Number of Character Traits (Based on Evans's data)

PHYSIOGNOMIC TRAITS	CHARACTER TRAITS						
	OPTIMISM	ACTIVITY	AMBITION	WILL-POWER	DOMINATION	POPULARITY	BLONDNESS
Convexity, whole face with nose ..	+.10	−.05	−.17	−.13	−.11	−.03	−.20
Convexity, chin to eyebrow, with nose	+.13	+.01	−.13	+.13	−.08	−.11	+.03
Convexity, whole face without nose ..	+.02	−.24	−.17	−.11	−.13	−.27	−.04
Convexity, chin to eyebrow, without nose	+.37	+.39	+.33	+.34	+.24	+.17	+.03
Convexity of upper face, with nose	−.06	−.08	+.04	+.06	+.08	−.17	−.02
Height of forehead from eyebrow to hairline	−.17	−.29	−.23	−.39	−.22	−.10	−.21
Blondness	−.26	−.02	+.05	+.28	+.14	+.03	

(After Hull)

with all the character traits. If the coefficients are reliable, low forehead may tend to indicate optimism, will, etc. However, the small number of cases and the high values of the probable errors make any conclusion to this effect unwarranted.

An analysis of these various investigations reveals a constant failure to confirm the claims made by character analysts. It may be, as Dunlap has suggested, that certain individuals engaged in character analysis

have a talent for diagnosing through an observation of details of behavior not subjected to analysis. It would be interesting if these experts would submit to experimental study as a means of determining their capacity in this direction. Unfortunately, attempts to gain co-operation generally fail. The author, for example, recalls an attempt of this kind which he made in co-operation with Professor Thurstone some years ago, and which resulted in a diplomatic and very final refusal on the part of the leading exponent of a character analysis system to under-go such examination. Ford [52] has recently had an opportunity to test such a system with the co-operation of its exponents. He was asked by the promoters of "Vitosophy," a new system, to make an impartial test of its validity. The signs used in the system included measurement of skull dimensions and curvatures, blondness or brunetteness of the subject, heat of breath on the back of the examiner's hand, the formation of the teeth and the character of the mouth. Only 20 cases could be examined by the proponents of the system because of the large amount of work involved, and the number was dropped to 18 because of technical difficulties. All subjects were garbed in plain gray and did not speak, thereby eliminating clues which might have otherwise been obtained. The analysts graded each subject on mathematics, written speech, general science, general intelligence, mechanical ability, general scholarship, and musical ability. Mathematics, written speech, general science, and scholarship were checked by college grades; general intelligence by Army Alpha scores; and mechanical and musical abilities by self ratings. A lottery box for random drawing was used to show how the ratings of the analysts compared with those made by chance. The correlations obtained by "Vitosophic" readings and by lottery were much alike, ranging from — 0.55 to + 0.32 for the readings, from — 0.38 to + 0.24 for the lottery, and averaging — 0.08 and — 0.01 respectively. According to the assumptions of "Vitosophy" all correlations with trait gradings should have been positive. Actually 4 of 7 were negative—approximately the number one would expect on the basis of chance. It is safe to say, as Ford indicates, that the use of "Vitosophy" in predicting success in the university is worthless—and there is reason to believe that the system would be no better used for industrial purposes.

The present status of physiognomic systems of character analysis has been well summarized by Symonds who has pointed out the "brazenness and shamelessness with which the charlatans, and there are many of them, push forward their claims. They usually have something to sell, and they make their living by selling it. Their assertions are dressed up in the most attractive way. They play upon the common foibles and weaknesses of mankind, who live in hopes and who are seeking praise and encouragement." [53]

[52] A. Ford, "A Check on Character Analysis," *Pers. J.*, 9 (1930), pp. 121–123.
[53] P. M. Symonds, *Diagnosing Personality and Conduct*, New York, 1932, p. 530.

CHARACTER ANALYSIS BY HANDWRITING

A number of the systems of character analysis depend on psycho-physiological rather than upon physiognomic signs. Among these there is, particularly among Europeans, a renewed emphasis upon hand-writing as a possible clue to the personality traits of an individual. Roback's description of graphology as one of the most promising of the psycho-diagnostic systems is an indication of the place accorded to this diagnostic method by a number of investigators.[54]

Among the most elaborate systems of graphology are those devised by Klages [55] and Saudek.[56] The latter particularly has submitted to painstaking analysis the detailed characteristics of penmanship and formulated definite rules for the interpretation of handwriting in terms of character qualities.

Among industrial investigation in this field is a study by Kügelgen [57] who finds that ratings on qualities of 48 printing apprentices based on an examination of handwriting coincide with tests of mental ability and intelligence in 66 per cent of the cases, and nearly coincide in 21 per cent of the cases. Hall [58] concludes that handwriting furnishes a suitable criterion for predicting success in commercial occupations from a study involving the rating, by 34 judges, of the competency of 19 students in a commercial school, and a correlation of ratings by graphologists with ratings of achievement. Klages [59] has submitted the handwriting of individuals in diverse occupations to 12 graphologists in 4 countries and finds a high degree of coincidence among the judgments expressed by these independent observers.

Couvé,[60] on the other hand, finds reason for denying the validity of handwriting in predicting fitness for work on the basis of a study involving the measurement of vocational aptitude for the occupations of ticket agent and locomotive engineer. Observers untrained in graphology were found to exhibit as high a degree of accuracy in predicting success from handwriting as the exponents of graphological systems of character analysis. Schorn [61] has tested the validity of graphological techniques by asking 5 graphologists to express independent judgments on one subject. A detailed analysis by this investigator shows a marked disagreement among the graphologists and an ubiquity of empty phrases and statements of very general application.

[54] A. Roback, *Personality*, Cambridge, 1931, pp. 54–64.

[55] L. Klages, *Handschrift und Charakter* (Rev. Ed.), Leipzig, 1929, pp. 258; *The Science of Character*, London, 1929, pp. 308; *Graphologisches Lesebuch*, Leipzig, 1930, pp. 291.

[56] R. Saudek, *Experiments with Handwriting*, New York, 1929, pp. 389.

[57] G. V. Kügelgen, "Graphologie und Berufseignung," *Ind. Psychot.*, 5 (1928), pp. 311 ff.

[58] M. Hall, "Die Schriftbeurteilung als Methode der Berufsauslese," *Psychot. Z.*, 1 (1927), pp. 15–33; 83–92.

[59] L. Klages, *Graphologisches Lesebuch*, Leipzig, 1930, pp. 291.

[60] R. Couvé, "Graphologische Berufseignungsuntersuchungen," *Ind. Psychot.*, 3 (1926), pp. 114–117.

[61] M. Schorn, "Untersuchungen zur Kritik der graphologischen Gutachten," *Ind. Psychot.*, 4 (1927), pp. 359–368.

The negative evidence of Couvé and Schorn generally agree with the findings of early studies by Binet,[62] and of a more recent careful laboratory investigation by Brown, working under the direction of Hull.[63] In this the investigator duplicated procedures used in earlier studies by Hull and Montgomery.[64] From a survey of the literature there were selected 6 character traits concerning which there was fair

TABLE 21

Correlations Between Character and Handwriting

	SPEARMAN RANK-DIFFERENCE COEFFICIENTS
Ambition with upward sloping lines	— .20
Pride with upward sloping lines	— .07
Bashfulness with fineness of line	— .45
Bashfulness with lateral narrowness of m's and n's	+ .38
Forcefulness with heavy lines throughout	— .17
Forcefulness with heavy bars on t's	— .06
Forcefulness with heavy bars on t's, corrected for size of writing	+ .27
Perseverance with length of bars on t's	+ .00
Perseverance with length of bars on t's, corrected for size of writing	+ .16
Reserve with tendency to close a's and o's	— .02

(After Hull)

agreement among graphologists and which were held to be associated with traits of handwriting susceptible to objective measurements. In the experiment by Hull and Montgomery 17 university students, belonging to a medical fraternity, rated one another on each of these traits. Each also copied a piece of prose on the same kind of paper, on the same desk, and with the same pen. The samples of handwriting were then submitted to microscopic measurement and the measurements correlated with the joint judgment of the character traits of the men. Only two correlations were obtained above .30. The resulting coefficients are shown in Table 21. Four of the ten are negative. Two of the coefficients, + 0.38 and — 0.45, are large. In order to check these values empirically, 10 rank order coefficients were computed from chance drawings of 17 numbered blocks arranged in series comparable with the data in Table 21. A coefficient of + 0.47 and one of — 0.26 was obtained in this way, the average of all being practically zero. In other

[62] A. Binet, *Les Révélations de l'Écriture d'après un Contrôle scientifique*, Paris, 1906, pp. 257.

[63] C. L. Hull, *op. cit.*, pp. 147–152.

[64] C. L. Hull and R. B. Montgomery, "An Experimental Investigation of Certain Alleged Relations Between Character and Handwriting," *Psych. Rev.*, 26 (1919), pp. 63–75.

words, the coefficients shown in Table 21 represent nothing more than chance relations. The actual average of these coefficients is — 0.016 which, as Symonds aptly remarks, "represents the amount of assurance that one should give to the claims of graphologists." [65]

Brown's experiment, involving 30 subjects and practically the same procedures used by Hull and Montgomery, leads to similar conclusions. The results (Table 22), as did those of Hull and Montgomery, show

TABLE 22

Showing Coefficients of Correlation Between Traits of Handwriting and Various Traits of Character (Computations based on data of Lois E. Brown)

CHARACTER TRAIT	HANDWRITING TRAIT	CORRELATION COEFFICIENT (r)
Bashfulness	Width of down strokes	+ .11
Ambition	Tendency to upward slope as line crosses page	+ .23
Persistence	Width of down strokes	— .05
Persistence	Disconnected writing—per cent of breaks of line within words	— .03
Personal neatness	Neatness in appearance of writing	+ .23
Personal individuality	Individuality in appearance of writing	+ .15

(After Hull)

coefficients opposite in direction to those required for demonstrating the claims of the graphologists.

The experimental studies of handwriting, under adequately controlled conditions, do not support Roback's optimism with respect to this diagnostic device. In this field, as in others, many more investigations, involving a greater number of subjects and new avenues of approach are needed for a full exploitation of the possible resources of the technique in fitting workers to jobs.

[65] P. M. Symonds, *op. cit.*, p. 257.

XI. STANDARDIZATION AND ADMINISTRATION OF PSYCHOLOGICAL TESTS

The primary purpose of any selection procedure is to differentiate between those who do and those who do not possess the qualifications necessary for a particular kind of work. In addition to eliminating those who cannot meet the minimum requirements of the job, selection methods must be useful in grading those who possess the qualifications to varying degrees.[1] The analysis of procedures ordinarily employed in selection has shown that in many cases they fail to accomplish these objectives satisfactorily. Both experience and experiment have shown that the traditional techniques are subject to gross error, and that opinions based on them may be extremely misleading. The lesser susceptibility to error of the psychological test points to it as the logical technique to be employed in the objective measurement of fitness for work.

The principle of the psychological test is to use a sample of the individual's behavior, examined under standard conditions, to indicate his competency and other traits, and to predict his probable future behavior in a particular job.[2] It is apparent that in order to be successful such a sampling of behavior must be carefully chosen. For purposes of broad comparison, we may think of a warehouse stored with such varied products as oil, coffee, cloth, vinegar, canned fruits, etc. No single sampling of goods could be used to measure the quality of these varied products, inasmuch as it would be foolish to attempt to determine the quality of the coffee from a small sampling of the oil, or to test the wearing qualities of the cloth by opening a can of tinned food and sampling its contents. The analogy is far fetched, but in testing the qualifications of an individual there is the similar problem of making sure that the behavior which is sampled is characteristic of that which is required in the particular job for which he is being considered. It is quite possible, for example, to measure the time taken to run a hundred yards. This *may* give a clue to the time that the same individual will require to run a mile, or perhaps even an indication of his rate of discharge in many other activities. On the other hand, the speed of running a hundred yards may be far from symptomatic of either his ability to hold up in a mile race or the speed with which he can do the

[1] L. J. O'Rourke, "Saving Dollars and Energy by Personnel Research," *J. Pers. Res.*, 4 (1926), p. 355.

[2] A. W. Kornhauser and F. A. Kingsbury, *Psychological Tests in Business*, Chicago, 1924, pp. 3–4.

mile. Only by a direct comparison of performance under the two conditions is it possible to decide whether the one sampling of behavior is of any value in predicting another form.

Stated in other terms, this means that tests must be carefully selected so that they really tap the resources to be employed in the activities of the job. In addition, no test can be considered a scientific instrument unless it conforms to certain criteria of *clarity*, *consistency*, *objectivity*, and *dependability* which distinguish the completely standardized test from the casual questionnaire of the magazine section of the Sunday newspaper. The questions which must be asked about a test in order to determine whether they satisfy these criteria have been well stated by Kornhauser and Kingsbury, who have prepared a list of typical questions that the psychologist asks, for example, about a test of the pencil and paper type before he undertakes to use it.

"Are the questions worded absolutely unambiguously? How do you know?

Are they all of equal—or accurately graded—difficulty, so that one means as much, and should mean as much, in the score as any other?

Is there a fixed time limit? Why? Or why not? If so, is it made and kept absolutely uniform whenever the test is given?

Will a slow reader or a slow writer make a lower score than one who reads or writes rapidly? If so, is it a trade test or a reading-writing test?

Will any subject be certain to get the same score, no matter who gives the test? How do you know?

Will he be certain to get the same score, no matter who marks it? Is there any way in which a generous marker can score him higher than a hard marker could? If not, how has this personal element been eliminated?

Has the test itself been tested?

Why is 90 set as the passing mark? Did you decide arbitrarily? If so, what proof of the correctness of this figure have you? Did you decide by taking the test yourself? If so, what evidence have you that your performance is the correct standard? Or did you try it on a group of workers?

How many workers have you tested with it? Is this enough to constitute a reliable sample?

How did you pick out these workers? At random, or did you select cases favorable for your purpose?

Did the successful workers all score 90 or above? The poor workers 89 or below? If not, do you know how reliable it is in separating these groups?

How did you determine which are "good" and which "poor" workers? Was that a reliable method?" [8]

Such questions can only be answered in the course of a careful standardization of tests in accordance with principles of test development and validation developed as a result of extensive experimentation in this field. The administration of the test involves a similar consideration of many factors which influence the performance of the individual in the test situation and which affect the value of results obtained. The steps to be taken in standardizing and administering tests will be briefly

[8] *Ibid.*, p. 16.

discussed below. The length of this volume does not permit a detailed discussion of each step, although certain outstanding problems, such as those of *types of tests to be employed, criteria, administrative procedures in testing,* etc., will be considered at some length.[4] There will be no pretense of referring to the great variety of tests which have been employed for particular purposes. The occasional illustration represents a single example of hundreds and perhaps thousands that could be presented.

The survey of steps to be taken in the standardization and administration of tests for the selection of workers will be followed by a description in complete detail of one study carried through by the author in the development of tests for the selection of electrical substation operators. This study is described in its entirety as a point of reference for the research procedures in the development and use of psychological tests described in Chapters XI and XII. It also serves as an introduction for the less detailed description of experimental studies in particular fields included in Chapters XIII, XIV, and XV, none of which will be described in detail.

The steps necessary for standardization will be described in the order in which they would be taken in an ideal situation. However, the sequence will necessarily vary from study to study, and in every investigation there will be a certain amount of overlapping as various parts of the investigation are carried on simultaneously.

(1) JUSTIFICATION FOR THE DEVELOPMENT OF TESTS

The first step in the organization of a research program for the development of selection tests is to determine the need for such research. This involves an analysis of selection procedures in use at the time the investigation is started in order to determine whether the predictive value of one or more of these can be improved. It requires an estimate of the cost of operation of the new method in relation to possible savings in cost of turnover, spoiled work, accidents, cost of production, etc., and in relation to the gain in the way of improved adjustment of the individual worker.

The justification of research procedure involves further an examination of conditions to determine whether they are suitable for the objective evaluation of psychological tests. The investigator must make

[4] The student interested in a detailed description of procedures in test development are referred to W. V. Bingham and M. Freyd, *Procedures in Employment Psychology,* New York, 1926, pp. 269, which is probably the most complete manual, in English, specifically devoted to the step-by-step procedure in the development of tests for purposes of vocational selection. A more recent volume by C. L. Hull, *Aptitude Testing,* Yonkers, N. Y., 1928, pp. 535, represents probably the most comprehensive treatment of fundamental problems and techniques in the construction, validation, and calibration of "aptitude" tests. The reader interested in a further discussion of these problems and of underlying statistical methods should refer to this volume by Hull.

sure that there are enough employees doing the same work to make possible a reliable study, that adequate records are available to permit a comparison of test results with success on the job, etc. The general conditions of the plant require investigation as a means of deciding whether relationships between workers and management are such that there can be no distortion of results by an absence of co-operation on the part of any of those who must work together in the program of test development.[5]

(2) EXPLAINING THE PURPOSE OF THE STUDY

The second and often neglected step in the research program is to explain the purpose and scope of the investigation to workers and to supervisory officials who may be called upon to co-operate in it. It can be assumed that the executives in the organization will be interested and co-operative, inasmuch as they are responsible for the policy of initiating such a research project. There is no reason for assuming the same interest and co-operation on the part of others. There is always a danger, as Muscio has pointed out, of a misunderstanding of objectives, of a confusion between psychological tests and some of the bad practices prevalent in the early days of scientific management.[6] These dangers can only be avoided by awakening in workers and supervisory officers a true appreciation of the nature and purposes of the investigation. The following letter, sent by the Superintendent of Substations to operators, foremen, and supervisors as a preliminary to the author's investigation in the selection of electrical substation operators,[7] may serve as one example of a suitable introduction to a research program.

"Apparatus for the job is selected with more and more care," wrote the Superintendent of Substations,[8] *"why not apply more and more care to the selection of human beings for a particular job? We plan to develop a program looking to this end. There are switchboard operators who are more reliable than others. We hope to make a study of the qualities or characteristics of both groups. From the results obtained it is hoped to fashion a yardstick with which to measure applicants. An interesting point is that while all applicants will be measured, that is, tested, the results will not at first enter into the selection of men. As time goes on, performance records will be compared with the entrance tests with the ob-*

[5] W. V. Bingham and M. Freyd, *op. cit.*, pp. 9–12.
[6] B. Muscio, *Lectures on Industrial Psychology*, London, 1920 (2nd ed.), pp. 265–71. In this connection see critique of selection tests by F. H. Allport, "Psychology in Relation to Social and Political Problems," in *Psychology at Work* (Edited by Achilles), New York, 1932, pp. 247–52.
[7] See Chapter XIII, pages 260–73.
[8] E. O. Macferran (deceased), Superintendent of Substations, Philadelphia Electric Company.

ject of proving the value of the tests. Then, when, and if the worthiness of the tests is confirmed, they can be definitely adopted for entrance requirements. Let me repeat that the design, construction, and installation of equipment have been highly developed to a point where it might be fairly said that materials are more reliable than men. The opportunity is present for improving the human factor with a view of increasing the reliability of the product we sell to our customers, and we are proceeding to develop this idea by undertaking a study of switchboard job requirements, a study of operators and a study of future applicants for this work. I am sure that this investigation will engage the interest and attention of the entire Operating Department."

(3) JOB ANALYSIS

Job analysis—or the detailed study of the duties and requirements of the job—represents the third step in the preparation of selection tests. "Although governed by fundamental principles, the factors to be measured and the practical measurement of these in test form present for each position an individual problem." [9] The exact nature of these factors can only be determined by applying one or more of the job analysis methods described in Chapter IX.

(4) THE DEVELOPMENT OF CRITERIA OF VOCATIONAL SUCCESS

The standardization of tests and the evaluation of other selection methods involve a comparison between test scores and the success of workers on the job. There is no justification for undertaking a research program unless there is available a satisfactory standard of accomplishment on the job, technically known as a *criterion* of vocational success, with which test scores can be compared. As Bingham has pointed out, "many a study of methods of selecting people for jobs has led to ambiguous conclusions because of the inadequacy or unreliability of the criterion by which the methods were judged. All too often a research has passed through the laborious and expensive phases of making the job analysis, constructing ingenious tests, and giving the tests to numerous employees, before the investigator discovered that no adequate and reliable measure of individual achievement on the job was to be had." [10]

Objective Criteria

Criteria of vocational success may be divided into two groups, *objective* and *subjective*. Among the former, including factors which can be measured and expressed in objective terms, are such varied standards of accomplishment as:

[9] L. J. O'Rourke, *op. cit.*, p. 352.
[10] W. V. Bingham, "Measures of Occupational Success," *Harvard Bus. Rev.*, 5 (1926), pp. 1–10.

1. *Quantity of output.*
2. *Quality of output.*
3. *Amount of spoiled work.*
4. *Number of accidents.*
5. *Cost of accidents.*
6. *Number of breakages.*
7. *Length of service or stability on the job.*
8. *Earnings on a commission basis.*
9. *Earned bonus.*
10. *Rate of advancement.*
11. *Standard Trade Examinations.*
12. *Number of operating mistakes.*

The choice among these criteria depends upon the nature of the job and upon the aim of the research program. For example, from the management's point of view a successful cab driver is one who maintains a high level of gross income and net earnings, who avoids accidents, reports for work regularly and punctually each day, and who represents the company favorably in his dealings with the riding public. In a research program involving such employees, the investigator may be interested solely in the reduction of accidents and for this reason will use only the number or cost of accidents, or both, as a standard of the worker's accomplishment on the job.[11] On the other hand, the objective may be to predict the probable earnings of applicants for employment. Under these conditions the investigator will disregard all other criteria and use earnings as the single measure of success on the job. In other instances, one criterion will be employed in determining the value of one measuring device and a second in evaluating the usefulness of other techniques.[12] In one study,[13] the author has employed *commissions* earned by taxicab drivers as a criterion in determining the value of an application score; [14] *number of accidents* in investigating the validity of a test similar to that used in the selection of motormen (described on pages 292–94); and drivers' *merit records* in examining the suitability of a mental alertness test for cab drivers (illustrated on pages 227–28) used in measuring general adaptability to the job.

The variety of possible objective criterion combinations is also illustrated in the use by Link of average number of shells inspected per hour for one month in devising tests for shell inspectors.[15] In the development of tests for mail distributors O'Rourke has combined (a) average number of pounds of first class mail distributed by each employee during a period of 6 months, together with the amount of time in minutes spent on this distribution; (b) the records in a monthly case examination measuring the rate and accuracy with which each worker can distribute into his distribution case; with (c) a subjective criterion in the

[11] A. J. Snow, "Tests for Chauffeurs," *Ind. Psych.*, 1 (1926), pp. 30–45.
[12] D. Wechsler, "Tests for Taxi Drivers," *J. Pers. Res.*, 5 (1926), pp. 24–30.
[13] An unpublished study of cab drivers employed by the Yellow Cab Company of Philadelphia.
[14] See Chapter X, pages 182–85.
[15] H. C. Link. *Employment Psychology*, New York, 1919, p. 30

form of foreman's ratings.[16] Finished products made by boys in introductory shop courses, results of final work tests given in the same courses, and an information test have been used by the University of Minnesota group in an investigation on the measurement of mechanical ability.[17]

The nature of other objective criteria that have been employed will appear in the discussion of individual studies in the chapters which follow.

Rating Scales

In addition to objective records of production or efficiency on the job, investigators have employed subjective estimates of achievement in evaluating selection methods. These are ordinarily expressed in the form of a *rating scale,* which represents an instrument for recording judgment on the possession or non-possession by a worker of the traits making for success on the job and on the extent to which he expresses these in his work.

The most popular form of rating scale is the so-called *graphic rating scale.*[18] This consists of a list of traits or activities to be rated and of various adjectives or descriptive phrases denoting the several gradations of a particular trait or activity. The descriptive phrases are set below a continuous horizontal line representing the range of the quality. The rater is instructed to indicate with a check mark the point on the line corresponding most nearly to the degree of the qualification found in the worker who is being rated. He is guided in this by the descriptive adjectives or phrases that define the various degrees of excellence in that quality. In evaluating the ratings a stencil or scale is prepared which divides the line into equal divisions, making it possible to convert each check mark into a numerical score. An example of such a graphic rating scale, used in following-up electrical substation employees, is shown on pages 207–09. In this case 10 divisions are used in translating the position of check marks into numerical scores.

In some instances, the actual numerical score assigned to each division of the line appears on the rating scale. In this case the rater is again guided by the descriptive terms, but he selects the score which is to be received on each particular trait by the individual who is being rated.

There are a number of additional forms for rating frequently employed in the industrial situation. Among these is the *man-to-man comparison scale,* originally developed at the Carnegie Institute of Technology for the selection of salesmen and later adopted for use in

[16] J. O'Rourke, *op. cit.,* p. 358.

[17] D. C. Paterson, R. M. Elliott, L. D. Anderson, H. A. Toops, E. Heidbreder, *Minnesota Mechanical Ability Tests,* Minneapolis, 1930, pp. 199–201.

[18] "Memorandum: Employees' Rating Scale," *Industrial Relations Section,* Princeton University, November, 1930, p. 2.

Form PX-500 3/29

PHILADELPHIA ELECTRIC COMPANY
STATION OPERATING DIVISION—SUBSTATION SECTION
STATION PERSONNEL PERFORMANCE REPORT

Name————————— Date—————————
Position————————— Substation—————————
Employee Rated by—————————

Instructions for making out this report:—Rate this man on the basis of the actual work he has been doing since the date of the last report. Before attempting to report on him it is necessary to have clearly in mind the exact qualities on which he is being rated. For this information read the definitions very carefully. In each quality compare the man with other assistant operators who have worked under you. Place a check on the line directly above the term which best describes the man's standing on the quality. If you think that he rates somewhere between the two terms, you may place a check mark between them.

1. GENERAL OPERATING INFORMATION					
Consider the man's knowledge of the substation, including wiring diagrams, the nature and purpose of the equipment, and the other general *information about the job that* has been given him; as found in the Operating Handbook, Circular Letters, etc.	Unusually detailed	Well informed	Fairly complete	Meagre	Altogether inadequate
2. ROUTINE OPERATING PROCEDURE					
Consider the man's reliability and thoroughness in making routine readings and observations.	Makes accurate and complete readings and observations	Seldom makes errors and omissions in readings and observations	Often makes errors and omissions in readings and observations	Observations and readings must usually be checked for accuracy and completeness	Altogether untrustworthy

3. ROUTINE SWITCHING AND BLOCKING					
Consider the man's ability, accuracy and carefulness in doing assigned routine switching and blocking.	Does the job very accurately and carefully	Can generally be depended upon	Occasionally careless and inaccurate. Must be corrected frequently		Makes errors Very careless Undependable
4. ROUTINE CARE AND MAINTENANCE OF EQUIPMENT					
Consider how well the man takes care of, repairs and adjusts the equipment.	Makes an excellent job	Makes a satisfactory job	Work barely passes inspection	Usually makes a poor job	Always makes a poor job
5. INTERRUPTIONS, EQUIPMENT FAILURES AND UNUSUAL OCCURRENCES					
Consider the man's habits in reporting unusual conditions and his ability to handle minor troubles or unusual occurrences in the substation.	Very effective in all new or unusual circumstances	Usually reports unusual occurrences & usually able to handle most unusual circumstances without difficulty	Occasionally neglects to report trouble. Is able to get by	Neglectful in reporting trouble & becomes "Lost" when the unusual happens, but manages to handle the situation with help	Generally irresponsible. Loses his head completely. Unable to handle any unusual situation
6. ROUTINE CARE OF BUILDING AND PROPERTY					
Consider how well the man performs his duties in exercising routine care of the building and property.	Always does his job very well	Usually does his work O.K.	Just gets by	Often has to do the work over again	Always makes an unsatisfactory job

7. CO-OPERATIVENESS

Consider the man's success in co-operating with the other members of the substation force, i. e. in working smoothly with the others.	Actively seeks to co-operate	Usually willing to do as the rest of the men do	Occasionally co-operates	Difficult to get any co-operation	Not at all co-operative

8. INDUSTRY

Consider the man's application to the duties of the job, day in and day out.	On the job all the time	Usually on the job	Just gets his work done	Has to be continually prodded to get work done	Neglects work consistently

9. ADHERENCE TO GENERAL REGULATIONS

Consider the man's adherence to regulations covering conduct in the station, uniform, reporting, and other general Company rules.	Excellent	Generally satisfactory	Usually lax	Negligent

10. REMARKS (Place here any additional comments about the man's progress that you care to make)

rating officers in the United States Army during the World War.[19] In this the rater prepares a master scale by selecting for each trait the best and worst man in a group of men actually known to him. He then selects a man of average ability and, following this, 2 other men, one midway between the highest and the average man, and the other midway between the lowest and the average man. These 5 men serve as standards with which to compare all of the other members of the group to be rated with reference to the trait in question. Arbitrary numerical values may be assigned to the steps in the scale assigned to these 5 men. This procedure necessarily involves the preparation of a separate master scale for each of the traits on which ratings are to be made. In practice this proves to be a cumbersome technique. Moreover, difficulties in selecting men for the standard scale, the variations in such selection by different supervisors and others rating the same group, etc., have resulted in a gradual increasing disuse of this type of rating scale.

Other types of rating scales which have been employed may be briefly described.

1. *Descriptive Scale.* This form of rating scale is essentially the same as the graphic rating scale in the sense that descriptive adjectives and phrases are used to describe different grades of ability from one extreme to another. However, in this type of scale no attempt is made to translate the ratings into numerical terms.

2. *Order of Merit Scale.* These require the rater to range the group in order of merit on each trait.

3. *Numerical Rating Scales.* In such scales the rater judges each man in terms of a number or percentage in much the same way as school examination papers are ordinarily graded. A rating of *100 per cent* or *10,* for example, assumes perfection on the trait being rated, whereas, *10 per cent* or *1* implies that the man does not possess the particular trait under consideration. In some cases, a line is put opposite the quality to be rated and the rater has only to put a check mark at the proper point on the line as follows:

	0 1 2 3 4 5 6 7 8 9 10
JOB KNOWLEDGE	______________________
LEADERSHIP	______________________

At times a key is provided to define each value:—

100 per cent or 10 means *distinguished*
90 per cent or 9 *excellent*
80 per cent or 8 *good*
70–60 per cent or 7 and 6 *fair*
50 per cent or 5 *average*
40–30 per cent or 4 and 3 *below average*
20–10 per cent or 2 and 1 *poor.*

[19] M. Freyd, "An Appraisal of Relative Merits of Types of Rating Scales and Their Use," Amer. Manag. Assoc., *Convention Series* No. 38, 1926, p. 4.

4. *Alphabetical Rating Scale.* This is essentially the same method as No. 3 (numerical), but letters, instead of numbers, are employed to distinguish degrees of excellence on the trait in question. So, for example, A or E may stand for excellent, B or G, good, C or F, fair, and D or P, poor.

5. *Check-List Rating Scale.* This is perhaps the simplest type of rating scale, inasmuch as the rater is only required to give his judgment in the form of a "yes" or "no" answer to the question as to whether the man possesses the trait which is being rated.

6. *Linear Rating Scale.* In such scales a straight line is drawn to the right of each trait to represent the range of ability—one end representing the least amount and the other the greatest amount. On this type of scale the rater arbitrarily places a check along this line at a point corresponding to the subject's standing on the trait.

Although all these types of scales have been employed, the graphic rating scale, the man-to-man rating scale, and the descriptive rating scale are probably the ones most frequently employed by industrial investigators in obtaining estimates on accomplishments of workers on the job. Such scales are used not only as criteria in the development of selection tests, but are even more frequently employed in procuring periodic ratings of progress as aids in transferring and promoting workers; as a basis for wage increases; in evaluating effects of training; and in many other situations where it is necessary to obtain information concerning the adjustment of the man on his job. Regardless of where they are employed and, *to some extent,* regardless of the type used, rating scales are subject to certain errors which limit their usefulness as criteria in the development of selection tests, and in other connections. These limitations will not be discussed in detail in this chapter.[20] Among the chief difficulties in the use of rating scales are individual differences in rating tendencies, the existence of a lenient tendency in rating, the inclination to assign similar grades on all traits, supplemented, at times, by a tendency to rate particular traits either very high or very low, etc. Added to these are defects occurring frequently in the construction of the scales themselves, such as the use of vague, general descriptions of traits to be rated and of vague descriptive terms and phrases. Such deficiencies become more serious

[20] For a discussion of the possibilities and limitations of rating scales, and of experimental methods to be used in their evaluation see H. O. Rugg, "Is the Rating of Character Possible?" *J. Ed. Psych.,* 12 (1921), pp. 425–38, 485–501; 13 (1922), pp. 30–42, 81–93; D. G. Paterson, "Methods of Rating Human Qualities," *Ann. Amer. Acad. Pol. Soc. Sci.,* 110 (1923), pp. 81–93; F. A. Kingsbury, "Analyzing Ratings and Training Raters," *J. Pers. Res.,* 1 (1922–23), pp. 377–383; "Making Rating Scales Work," *J. Pers. Res.,* 4 (1925), pp. 1–6, A. W. Kornhauser, "What are Rating Scales Good For?" *J. Pers. Res.,* 5 (1926), pp. 189–193; "Reliability of Average Ratings," *J. Pers Res.,* 5 (1926), pp. 309–317; "A Comparison of Raters," *J. Pers. Res.,* 5 (1927), pp. 338–344; N. Kneeland, "These Lenient Tendencies in Rating," *Pers. J.,* 7 (1929), pp. 356–366; A. Ford, "Neutralizing Inequalities in Rating," *Pers. J.,* 9 (1931), pp. 466–469; F. F. Bradshaw, "Revising Rating Techniques," *Pers. J.,* 10 (1931), pp. 232–245. See also P. M. Symonds, *Diagnosing Personality and Conduct,* New York, 1932, Chapter III, pp. 41–121.

when there is a failure to train those who employ rating scales as a means of making most advantageous use of them. The procedure to be followed in overcoming such difficulties has been well stated by Paterson in the form of a series of guiding principles:

"1. *Records concerning supervisors' estimates of subordinates should be accumulated and filed in* advance *of any emergency requiring such estimates as a basis of decision.*

2. *Estimates should be based on qualities that are defined unambiguously in advance.*

3. *Qualities to be rated should be defined in objective terms so far as possible and should be grouped according to the accuracy with which they can be judged.*

4. *Each quality to be rated should refer to one type of activity carried on or to one type of result achieved by those to be rated.*

5. *Ratings should be confined to past or present accomplishments.*

6. *The list of qualities to be rated must be related directly to the type of work performed by those to be rated.*

7. *The method of recording one's ratings should be easily understood and easily complied with.*

8. *Estimates should be expressed in a uniform manner by all raters.*

9. *A statistical method of correcting for the tendency to rate "too high" or "too low" should be employed.*

10. *Ratings should be accepted and filed for use only from those who have proved themselves capable of accurately judging human qualities.*

11. *Each executive should rate his subordinates on the first quality, then, rearranging the order at random, he should rate them on the second quality and so on for the remaining qualities.*

12. *As many judges as possible should be employed in rating a given person and an average of all the available ratings should be used as the index for that person.*" [21]

Problems in the Selection of Suitable Criteria

The value and results of a research program in vocational selection will depend in no small measure upon the character of the criteria employed. These—as well as the tests themselves—must be *reliable* and *valid,* that is, they must be consistent in their classification of the same employees at different times and they must give a true index of the proficiency and achievement of each worker on his job. In general, as Weber has pointed out, the type of criteria employed still represents a "dark chapter in the application of psychology in industry." [22] The unreliability of ratings and rankings are stressed by practically all who write on the subject, but in a large number of experiments reported

[21] D. G. Paterson, *op. cit.,* p. 82.
[22] W. Weber, *Die praktische Psychologie im Wirtschaftsleben,* Leipzig, 1927, p. 121.

in the literature these are the only criteria used.[23] This is true not only of office and professional jobs, where the formulation of objective standards is possibly most difficult, but also in the case of non-office occupations where records of production and similarly less subjective standards may be more easily obtained. Accurate measurement of the type used by Patten [24] in the case of lathe operation, and more recently in the Minnesota study,[25] are still rare enough to be outstanding.

In many instances attention in the investigation is centered not upon the validity and reliability of the criteria, but upon the correlation of tests with criteria not submitted to analysis. However, it is also true that frequently the inadequacy of criteria is not at all a reflection upon the investigator, but upon the unsatisfactory character of records kept by industrial establishments.[26] In other instances the complexity of conditions seriously handicaps the search for a reliable and valid criterion. The problems involved in such a search appear clearly in the obstacles that have been encountered in answering the "question of who is a good motorman." [27]

An illustration from the experience of the author in a lock manufacturing plant may serve to illustrate the influence of conditions not under the control of the investigator. In this plant very accurate production records over a long period of time were available for the assemblers, punch press operators, and drill press operators who were the subjects of the experiment. These seemed to be absolutely valid criteria until an examination revealed two distinct levels of production among girls employed in the plant. An examination of the data showed that these levels were along national lines, the average of Irish girls being decidedly above that of Polish girls. Conferences with executives of the company and a review of plant records showed that there was a consistent tendency for the one group to earn less than the other when employed on the same type of work on a wage incentive plan of payment. A further analysis suggested that this difference in earnings reflected no difference in the inherent competency of the two groups, but represented the influence of home conditions upon earnings. In general, Irish girls were in the habit of turning over to the parents a stated portion of their earnings each week as their contribution to household expenses. The remainder was spent by the girl for clothes, amusement, etc. Among the Polish girls, on the other hand, it was the custom to turn over the entire salary to the parents who gave back what they

[23] M. S. Viteles, "Standards of Accomplishment: Criteria of Vocational Selection," *J. Pers. Res.*, 4 (1926), pp. 483–486.

[24] E. F. Patten, "An Experiment in Testing Engine Lathe Aptitude," *J. App. Psych.*, 7 (1923), pp. 16–29.

[25] D. C. Paterson and others, *op. cit.*, pp. 144–202.

[26] W. V. Bingham, "What Industrial Psychology Asks of Management," *Bull. Taylor Soc.*, 9 (1924), pp. 1–17.

[27] M. S. Viteles, *op. cit.*, pp. 484–485; S. M. Shellow, "Research in the Selection of Motormen," *J. Pers. Res.*, 4 (1925), pp. 222–237; S. M. Shellow and W. J. McCarter, "Who Is a Good Motorman?" *Pers. J.*, 6 (1928), pp. 338–343.

saw fit to the girl for lunches and incidental expenses. This created an enormous difference between the two groups in the incentive for increasing production and earnings. Extra earnings on the part of the Irish group could be used to satisfy personal pleasures, whereas the Polish girls had no such incentive to raise production above the minimum standard set by the plant. This situation made it impossible to use production records and earnings as criteria in the development of competency tests.

The character of complicating conditions will vary with individual plants and with individual jobs. In general, the development of adequate criteria of success and failure in a given job probably involves an accumulation and interpretation of standard data furnished by a number of firms over a long period of time.[28] Such an extensive and intensive study of criteria in one or more industries offers a fertile field for basic research—possibilities which far exceed those of the construction of new tests and their comparison with inadequately evaluated standards of accomplishment which are occupying most investigators. Basic research in this field affords not only an opportunity for the development of accurate standards of accomplishment, but for an enrichment and refinement of methods for the study of criteria. Such research is essential if selection is to reach the level of certainty in prediction to which it aspires.

(5) SELECTION OF EXPERIMENTAL GROUP

The step following the development of criteria is the selection of workers to be included in the experimental group. In general, the main experimental group will consist of a group of workers already employed on the job whose accomplishments can be compared with test results. This group should be supplemented at some time in the course of the experiment by a group of applicants tested prior to employment, placed on the job regardless of test scores, and followed up to determine the relationship between scores obtained prior to employment and accomplishment on the job after a suitable period of training and experience. The selection of the members of the first of these two groups is complicated by a number of problems. In some instances it may be possible and desirable to use all of the employees engaged in the job under consideration. At other times the size of the group, the presence of older workers, and other factors may make it desirable to select as the experimental group a proportion of the workers engaged on the job.

When the entire group is not used, the chief consideration in the selection of the experimental group is to make certain that this group

constitutes an adequate *sampling* of all the workers. There must be a representation of *poor, average,* and *good* workers in a proportion equivalent to their occurrence in the entire group. Age, schooling, and certain other factors must, in so far as possible, be kept constant, and if not kept constant subjected to analysis to determine the influence of each factor upon efficiency on the job and upon test scores. It is probable, for example, that differences in the amount of training and experience on the job will exist in the group. Under such circumstances provision must be made either to limit the range of experience in the experimental group or to treat findings statistically in order to make constant the effect of these particular variables. In general, the following rules may be broadly applied in the selection of the experimental group:

(1) Conditions of work must be constant for all workers included in the experimental group.

(2) Where workers are of different sex, both sexes should be included, but an analysis made in order to determine the possible influence of sex differences.

(3) The age range of the group should not be too great. It is of particular importance to exclude from the experimental group, especially where motor skills are involved, workers above the age of 40 or 45, so as to eliminate the possible effect of age upon adaptability to the new motor situations represented in the tests.[29]

(4) Experience on the job should likewise be confined to as limited a range as possible. The author has found it desirable, for example, in testing motormen, to confine the range of experience to a period of 3 years, inasmuch as the accident curve of such employees ordinarily drops rapidly after approximately 2 years of service.[30] The limits of the range of experience will depend upon the total number of workers, in other words, upon the possibility of getting an adequate sampling of good, average, and poor workers within a limited range of service on the job.

(5) In the opinion of the author, workers who object to going through the tests should not be included in the experimental group.[31] Coercion or "moral suasion" should not be applied in forcing workers to act as subjects in the research program.

In the case of the group of new employees, the experimental group is set up by examining and following-up, for a given period of time, all applicants hired by the Employment Office in accordance with the standard which it has been employing in selection prior to the development of the psychological tests.

(6) THE SELECTION AND CONSTRUCTION OF TESTS

The selection of the tests to be used in the experimental investigation constitutes one of the major problems in the research program for the development of tests. The selection of tests will depend upon the nature of the activities of the job and upon the character of the qualifications as determined by means of the job analysis. Inasmuch as vocational selection involves a measurement of *proficiency, competency, temperament and character,* and *interest,* the tests employed will naturally be of these four kinds. The author will consider more specifically below the varieties of tests to be used for the measurement of each of these factors. It is important, however, before going on with this to mention a few general considerations which must be given weight in the selection and construction of testing material.

In the first place, the tests must be objective.[32] As far as possible, they should be simple from the viewpoint of administration. Time and cost of administration must be given serious consideration in the selection of tests to be tried out in the research program. Like all other measurement techniques they must be *reliable,* in the sense that the test will give practically the same results in the hands of different examiners and when applied to the same subjects at different times. The failure to establish the internal consistency or reliability of the test has been the stumbling block of many an investigation which has otherwise been satisfactory.

Tests have been classified with respect to the material employed There are, for example, *paper and pencil tests* in contrast to those making use of *apparatus* of one kind or another. Tests have been classified, with respect to administrative procedure, into *oral* and *written; language* and *non-language; self-administering* in contrast to those requiring the presence of an examiner; *self-recording* and *non-recording,* etc. Distinctions have also been drawn between *individual* and *group* tests; *speed* and *power* tests; *time-limit* and *work-limit* tests, etc.[33] The reader interested in such classifications is referred to the very extensive literature on mental testing.

The investigator in this field must be familiar with a great variety of tests already available for use in research programs in industry. There are numerous tests at present employed for one or another purpose in the school situation, the psychological clinic and the psychological laboratory which, perhaps with some modification of administrative technique, may be extremely useful in many industrial situations. The failure of industrial investigators to recognize this fact has resulted in an unnecessary and almost chaotic duplication of testing devices at a time when the more complete evaluation and standardization of existing apparatus and techniques are most needed. Such duplication of

[32] W. V. Bingham and M. Freyd, *op. cit.,* pp. 76–86.
[33] C. L. Hull, *op. cit.,* Chapter III.

test material is unfortunate from the viewpoint of scientific research. It also increases the cost of the research program in individual industrial organizations. Perhaps the first principle in the selection of tests is to survey manuals of mental testing [34] and the literature of industrial psychology for material which may apply in the particular research program engaging the attention of the investigator.

In spite of his desire to adhere to this principle the investigator may at times be forced into test construction. At such times he must be ready to apply the fundamental principles of test construction which are basic in developing a scientific testing instrument. Procedures for the selection and scaling of items, for the weighting of items in questionnaires, and of the individual units of a test battery cannot be discussed here, but familiarity with these procedures is a necessary qualification for the research work in the field of mental testing as applied to industry.[35]

Proficiency Tests in Industry

Success in many jobs depends upon skills acquired by the applicant either as the result of training or in the course of experience on the job for which he is applying. This is true of typists, stenographers, in many other office occupations, and in a great variety of skilled, technical, and professional jobs.[36] Attained skill is measured by means of the *Trade Test,* a device that can be used without trade knowledge on the part of the examiner for determining in objective, quantitative terms the degree of trade proficiency possessed by the person under examination.[37] Such tests were first developed for use in the Army during the late war, but the years since the war have been marked by an extension of their use in industrial establishments of diverse sorts.

Four types of trade tests have been employed in the measurement of attained skill. The first of these is the *Oral Test,* illustrated below. This is designed to test only "the information which the man has with regard to certain elements of his trade." [38] Such a test assumes, of course, that the informaton about a trade is an outgrowth of experience in the trade and an indication of skill in performing the technical operations of the trade. It is useful in testing only for such trades in which this assumption is found to be justified by experimental analysis.

[34] Among these may be cited G. M. Whipple, *Manual of Mental and Physical Tests,* Baltimore, 1915, pp. 688; A. F. Bronner, W. Healy, G. M. Lowe, M. E. Shimberg, *A Manual of Mental Tests and Testing,* Boston, 1927, pp. 287; F. Giese, *Psychotechnische Praktikum,* Halle, 1923, pp. 153; F. Gaw, "Performance Tests of Intelligence," *Ind. Fat. Res. Bd., Report,* No. 31, (1925), pp. 45; C. H. Griffitts, *Fundamentals of Vocational Psychology,* New York, 1924, pp. 372; G. E. Manson, "Bibliography on Psychological Tests," *J. Pers. Res.,* 4 (1925), pp. 1–28.

[35] A very complete discussion of technical and statistical procedures in test construction is included in the volume on *Aptitude Testing,* by C. L. Hull, cited elsewhere in this text. See also W. V. Bingham and M. Freyd, *op. cit.,* Chapters XIII–XVII inclusive.

[36] See Chapter XV, pages 311–13.

[37] J. C. Chapman, *Trade Tests,* New York, 1921, p. 8.

[38] *Ibid.,* p. 8.

ORAL TRADE TEST

Printer.—Compositor

Committee on Classification of Personnel In the Army

Trade Test Division

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QUESTION 1

Q. What does the proof reader's w. f. indicate?
A. Wrong font. Score 4

QUESTION 2

Q. What do you call a table on which the form is locked up?
A. Stone. Score 4

QUESTION 3

Q. In what do you assemble the type from the cases?
A. Stick. Score 4

QUESTION 4

Q. How are types made so that they can be placed in the stick in the proper way?
A. Nicked. Score 4

QUESTION 5

Q. What do you use to get the type perfectly level in the form?
A. Planer. Score 4

QUESTION 6

Q. What is the page number called?
A. Folio. Score 4

An example of the second type of test, the *Picture Trade Test,* is given below. (Figure 23.) This is similar in principle to the oral test, presenting "to the candidate pictures of tools, machines, materials, and products of his trade and requiring him to identify these and to indicate uses." [39] The advantages of this type are that it brings the appilcant closer to the actual trade, that it presents concrete visual images of objects instead of requiring him to build up in memory an image of the object or process he is trying to name.

The third type is the *Performance Trade Test.* This is a job so arranged as to require of the candidate a demonstration of his manual proficiency and his judgment in the use of the main tools of his trade.[40] (Plate IV.) Such a test places before the worker a problem taken directly from the job, and his proficiency as a worker is measured in

[39] W. V. Bingham, "Measuring the Workman's Skill," Nat. Soc. Voc. Ed., *Bulletin* No. 3, Proceedings St. Louis Convention, 1919, p. 5.

[40] *Bulletin* No. 3, Nat. Soc. Voc. Ed., p. 5.

quantitative terms on the basis of his success with this problem. In most cases the measurement is in terms of both quality of product and speed. In a test for typists, for example, not only would the quality of the final copy be examined, but also the speed at which a definite amount was produced. The rating based on product and speed is known as a

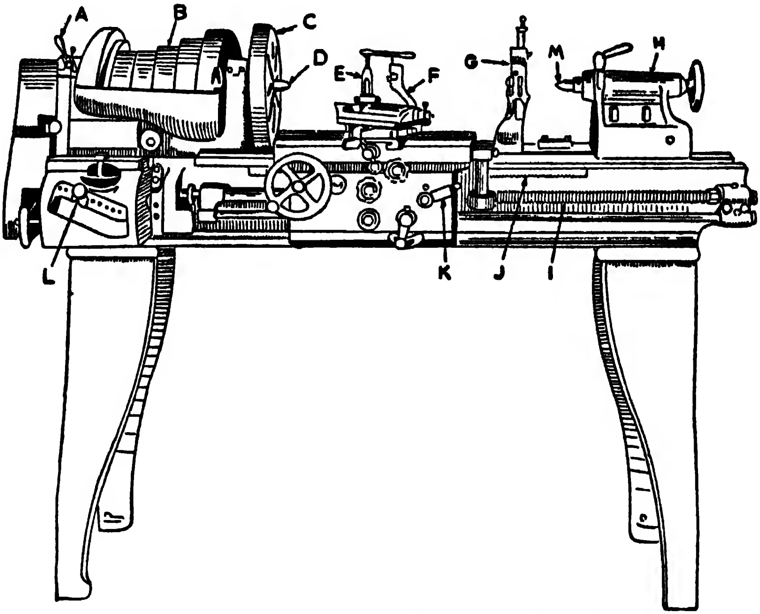


FIGURE 23. *Picture Trade Test Lathe Hand*

(*After Toops*)

LATHE HAND TEST [41]

1 What is the part at G called?
Ans. Steady-rest.
2. What letter shows the live center?
Ans. D.
3. What is the lever at K used for?
Ans. Screws (threads).
4. What do you call the part at C?
Ans. Face-plate.
5. What do you call the lever at A?
Ans. Back-gear.
6. What is the part at L used for?
Ans. Gears (change the gears).
7. What letter shows the cone?
Ans. B.
8. What letter marks the tail stock?
Ans. H.
9. What is the part at F called?
Ans. Follower-rest (follower).
10. What is the part at J called?
Ans. Rack.
11 What is the part at I called?
Ans. Lead-screw.
12 What is the part at E called?
Ans. Tool-post.

[41] H. A. Toops, *Trade Tests in Education*, New York, 1921, p. 8.

product-time rating. In other tests, such as the test for telephone and telegraph linemen and for magneto and ignition repairmen, emphasis is placed on the quality of the product alone (*Product Test*). In still other cases the speed with which the test is completed furnishes the significant index of skill (*Speed Test*). The test for steam fitters, for example, consists in making up a mitre radiator coil out of its 14 parts. If the job is not correctly done, or if it takes more than 115 minutes, the candidate is rated as a novice. A journeyman completes it in from 19 to 24 minutes, while if it is done in 18 minutes or less it is known that the man is an expert steam fitter.

As a general rule it is not necessary for the examiner to watch how the job is done. A few exceptions occur to this general rule. When testing a truck driver, an auto chauffeur, or a motorcyclist, the examiner must be seated beside the candidate, prepared to rate performance with respect to smoothness of starting, gear shifting, stopping, backing, turning, driving through a maze, coasting down hill with power off, using the engine as a brake, and so on; but even here the principle holds that the tester himself need not be a competent driver. The scoring in this case is in terms of how the job is done, the process of the job. This form of test is known as a *Process Test*.

The advantages of this type of a test are almost self-evident. It tests the most essential element of trade skill, the actual operating proficiency of the prospective worker. The disadvantages are largely in the difficulty and expense involved in designing and standardizing such tests and in the time and cost involved in their administraton.

Below is illustrated the fourth type of trade test, the *Written Group Test*. The usefulness of this type of test is exceedingly limited in industry, although it may have been of some slight use in solving the Army problem and may still be useful to large public employment agencies.

Bricklayers' List (Written group) [42]

Directions:

In the sentences below, there are four choices for a correct *sentence*. Only one of the four choices is correct. Draw a line under the *one* choice which makes the best sentence. If you are not sure, *guess;* an omitted answer will count as a wrong answer in determining your score. The first two sentences, *A* and *B*, are answered correctly as a sample for you. Read them carefully; then go on to question 1, question 2, and so on to the end of the list.

A. A half of a brick is called a: chunk, block, heel, <u>bat</u>.

B. Fire-bricks are laid in: concrete, cement, <u>fire-clay</u>, mortar.

Questions:

1. The top course of stone on a wall is called: coping, bond-stone, clip-course, capstone.
2. A brick set on end is called: upright, soldier, rowlock, stud.
3. Before plumbing up a corner, you should lay: 3 courses, 6 courses, 9 courses, 12 courses.

[42] J. C. Chapman, *Trade Tests*, New York, 1921, pp. 338–39.

4. A brick that is set on the narrow edge is called: stretcher, oarlock, rowlock, header.
5. In coming to a height, if there is a course of brick difference in the level, you would call it a: hunch, filler, line level, hog.
6. Filling-in the space between a front and back course of brick is called: slushing up, tempering, tuck-pointing, plastering.

The use of trade tests is not limited to production jobs in the factory. In the examination of typists and stenographers tests of actual typing proficiency and of skill in taking and transcribing notes have been effectually used in fitting workers to jobs.[43] The determination of skill in driving on the part of motor vehicle operators offers a wide field for the application of this type of test. Trade tests for truck drivers and for passenger car operators were developed as part of the battery used by the Army in the assignment of personnel. The test for truck drivers required a specially laid out plot of ground, 330 x 125 feet, and another, 50 x 36 feet, graded like the side of a hill. Another plot of ground was required for the test on passenger cars. However, no opportunities for driving in traffic were afforded in these tests. These and other disadvantages make the Army Trade Tests for drivers unsuited for use by industry. An example of a test which meets the requirements of industry is a standard procedure for measuring driving skill, devised by the author, that can easily be applied under city conditions by an inspector or group of inspectors trained in the use of the covering manual.

A Trade Test of Driving Skill

The procedure for giving this test requires that the operator be taken over a route which permits the inspector to observe every phase of safe and economical operation. The inspector lays out three standard routes, equal in general characteristics and difficulty, one of which is used whenever the test of driving skill is to be given.

The purpose in laying out optional routes is to make certain that the operator will have no exact knowledge of the ground to be covered prior to reporting for his driving examination. Descriptions of these routes are filed in the office of the Superintendent of the Transportation Division.

Procedure for Giving the Driving Test

The driving test starts and ends in the Company garage, so that the inspector may observe driving habits and the conduct of the operator in the garage as well as on the road.

The inspector in every instance sits beside the driver. He gives directions for starting, stopping, turning, etc., as required, but does not indulge in other conversation with the driver.

[43] M. Freyd, "Selection of Typists and Stenographers: Information on Available Tests," *J. Pers. Res.*, 5 (1927), pp. 490–510.

PHILADELPHIA ELECTRIC COMPANY
Transportation Division
MOTOR VEHICLE DRIVING TEST REPORT

Name:	**Payroll Number:**
Position:	**Dept.** **Referred by:**
Position Applied For:	**Examined on Truck.........Passenger Car........**
Driving Experience:	**Driving License:**

INSPECTORS' REPORT **DATE**

Place of Inspection: **Route Number:**

KNOWLEDGE OF REGULATIONS:	Poor............	Fair............	Good...........
GENERAL DRIVING ABILITY:	Poor............	Fair............	Good...........

ADDITIONAL INSTRUCTION AND PRACTICE REQUIRED:

COMMENTS:

Recommended............ Not Recommended............ for Driving Cert.

....
Inspector.

DETAILED DRIVING REPORT

A. Starting	J. In Traffic
B. Speed	K. Bad Weather Driving
C. Crossings	L. Clutch
D. Stopping	M. Gears
E. Turning	N. General Economy Features
F. Backing	O. General Safety Features
G. Passing Other Vehicles	P. Public Relations
H. Grades	Q. Changing Tires
I. Parking	R. Care of Equipment

During the examination the inspector carefully checks operating items such as those shown below and records on the *Motor Vehicle Driving Test Report* (page 222) the results of his observations, in accordance with a standard procedure provided for this purpose.

Inasmuch as it is never permissible to "ride on a flat tire," the ability to change a tire is examined as part of the test.

In order to give the rating under "Care of Equipment," the inspector examines the tool box, tire chains, and other items of equipment over which the driver of motor vehicle has complete charge.

Typical Observations Made by Inspector on Driving Test

A. *Starting*

1. Operator fails to start car smoothly.
2. Fails to use choke or spark.
3. Fails to use special devices for cold weather starting.
4. Fails to look in all directions before setting car in motion.

B. *Speed*

1. Too fast in traffic between streets.
2. Too fast at street intersections.
3. Too fast on suburban roads.
4. Too fast for wet streets.
5. Too fast in garage.

C. *Crossings*

1. Fails to have car under complete control at crossings.
2. Fails to look in both directions at crossings.
3. Tends to "fly signals" when yellow.
4. "Hogs" the crossing; fails to give vehicles or pedestrians the right of way.
5. Does not use horn when required at crossing.
6. Fails to take proper precaution in crossing railroad tracks.

D. *Stopping*

1. Fails to place hand out to warn following vehicles.
2. Applies brake suddenly—jerky stop.
3. Fails to look around before stopping.
4. Stops too far from curb.
5. Hits curb when stopping.

E. *Turning*

1. Fails to keep to the right when making right turn.
2. Fails to keep to the left or center when making left turn.
3. Fails to give hand signal before turning.
4. Looks at mirror but does not look out of window before turning.
5. Fails to look either at mirror or out of window before turning.
6. Violates local regulations in turning between crossings.
7. Turns crossings too short.

Educational Achievement Tests

In additional to tests of trade skill, there may occasionally be need in industry for the application of achievement tests measuring the attainments of the individual in the field of education. O'Rourke, for example, has made use of a test including problems in spelling and grammatical construction in the selection of typists and stenographers.[44] Tests of the same kind form part of the battery recommended by Thurstone for the selection of clerical workers. A simple language comprehension test may be used in the selection of semi-skilled workers for occupations in which the worker must be able to read well enough to understand safety posters aand special announcements issued from time to time by the company.

[44] L. J. O'Rourke, *Annual Report of the Director of Research,* U. S Civil Service Commission, Washington, D. C., 1930, pp. 36–37.

XII. STANDARDIZATION AND ADMINISTRATION OF PSYCHOLOGICAL TESTS (continued)

(6) THE SELECTION AND CONSTRUCTION OF TESTS (CONTINUED)

The Measurement of Competency

Competency represents the *potentiality* of the individual to profit from training and experience on the job and to develop into a satisfactory worker.[1] The determination of competency involves a measurement of general intelligence and of specialized abilities.

General Intelligence Tests

For the measurement of general intelligence there are available a variety of standard tests. A number of these, including the *Army group intelligence examinations;* the *Bureau of Personnel Research Test VI* (a spiral omnibus form of the Army Alpha); the *Otis General Intelligence Test* (Designed for Business Institutions); the *Otis Self-Administering Tests of General Intelligence;* the *Scott Company Mental Alertness Test* [2] have been used in industrial research and selection programs. In a number of instances, special tests of the general intelligence type have been prepared with content applying directly to the industry in which they are used, and with items and questions phrased in the terminology of the industry. An examination of this type is illustrated on pages 227–28, showing a section of a test devised by the author for the selection of cab drivers which gave satisfactory results in predicting the merit and demerit records of drivers.

The Measurement of Special Abilities

In general, there are three types of tests available for the measurement of special abilities: (1) *analytic,* (2) *analogous,* and (3) *work sample.*

1. The *analytic* type of test is designed to measure either one of a restricted number of the specific abilities which enter into the operations of a job. The use of this type of test presupposes a very careful analysis in terms of underlying, constituent abilities and the preparation of a battery of tests, each measuring one or more of those abilities which are most significant for success on the job. The results of these

[1] See Chapter VIII, pages 120–33.
[2] Described by A. W. Kornhauser, "Some Business Applications of a Mental Alertness Test," *J. Pers. Res.,* 1 (1922), pp. 104–111.

tests may be ultimately combined into a single score, or each test may be considered separately in determining competency for some particular part of the job.[3] In some instances results may be presented in the form of a profile showing the performance on each test expressed in either quantitative or qualitative terms. A further development of this technique is to compare the individual profile (individual psychograph) with one showing the requirements of the job (job psychograph) as a means of gauging competency for the job.[4]

Characteristic of the analytic type of test is a battery employed by German investigators in the selection of apprentices for the metal trade, which includes tests of *visual discrimination, space perception, kinaesthetic discrimination, manual dexterity,* etc.[5] The tests which the author has used in the selection of substation operators, described on pages 263–64, are also representative of the analytic type of test. So, for example, the *Learning Test* is designed to measure the ability of the applicant to learn a complex series of motor responses—an ability which is essential in the accurate operation of the substation. "Accuracy in following directions" is measured by the *Directions Test* (Plate II) involving 24 directions calling for the manipulation of the switch panels and boxes which make up the test. Moreover, in the case of this series, both a quantitative score and a profile showing the variability from test to test are employed in gauging the suitability of the applicant for the job.

The use of analytic tests generally involves a series of "a priori" assumptions concerning the nature of the ability tested.[6] There is always the possibility that the tests, although valid, do not measure the traits which they presume to tap.[7] However, in spite of this, the satisfactory results obtained through the use of such tests point to their serviceability.

2. The second type of test which may be employed in the selection of workers is the *analogous* test. In this the attempt is made to duplicate in one test the essential activities of the job,[8] either by reproducing in *miniature* the pattern of the job or by constructing a test which *simulates* the job without exactly reproducing it. The principle underlying such tests is that the essential feature of an activity is the *rela-*

[3] B. Biegeleisen, "Über den diagnostischen Wert psychotechnischer Eignungsprüfungen," *Ind. Psychot.*, 8 (1931), pp. 113–128.

[4] W. Poppelreuter, *Allgemeine methodische Richtlinien der praktisch-psychologischen Begutachtung*, Leipzig, 1923, pp. 19 ff., and F. Giese, *Handbuch psychotechnischer Eignungsprüfungen*, Halle, 1925, pp. 655 ff.

[5] See Chapter XIII, pages 278–82.

[6] Of course it is possible to select such tests by the "empirical" method, in which a long series of tests, selected at "random," are tried out and compared with the criteria. However, the cost in time and material of this method practically imposes a preliminary analysis and "a priori" assumptions upon the investigator. (See H. L. Hollingworth, *Vocational Psychology and Character Analysis*, New York, 1929, pp. 294 ff.; W. V. Bingham and M. Freyd, *Procedures in Employment Psychology*, Chicago, 1926, pp. 81–82.)

[7] W. Weber, *Praktische Psychologie*, Leipzig, 1927, pp. 105 ff.

[8] C. L. Hull, *Aptitude Testing*, Yonkers, N. Y., 1928, p. 67.

YELLOW CAB COMPANY

OF PHILADELPHIA

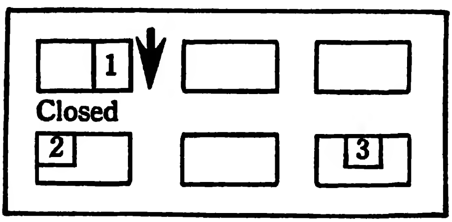
Test for Drivers

Compiled by

Morris S. Viteles, Ph.D., Consulting Psychologist

A...........
R...........
SCORE

34. In the drawing below make a line to show the SHORTEST route from house 1 to house 2 to house 3 following the traffic rules.
THE NUMBERED SQUARES STAND FOR HOUSES.
There are TWO TRAFFIC rules
   1. ALWAYS TURN TO THE RIGHT. No left-hand turns are allowed.
   2. Keep off the part of the street marked "CLOSED."



35. If you charge 30 cents per mile and 15 cents for each extra passenger more than one, how much will you collect for a 6-mile ride on which you carry 4 passengers?
   Answer: ....

36. If a taxicab bill is $7.55 and you are given a ten dollar bill, what is the SMALLEST number of coins you can give back in change?
   ....Dollars ....Halves ....Quarters
   ....Dimes ....Nickels

37. Answer the following question about the picture of the automobile accident which you observed:
   From what State is the automobile?
   Answer: ....

38. Above the first letter below make a cross. Draw a circle around the letter which follows it in the alphabet and a line from this to the last letter below.

J A R N P K L O S T V A

39. PUT A CROSS BEFORE THE BEST ANSWER TO THIS QUESTION.
If your cab broke down and there was no other cab to which to transfer your passenger, and the passenger refuses to pay what the meter has registered because he has not been carried to his destination, what would you do?
........Beat him with your crank handle until he paid.
........Hold him in the cab until a policeman came to settle the dispute.
........Ask him to give you his name and address and allow him to go.
........Allow him to go without paying, but follow him until you came across a policeman whom you could ask to arrest him.

---

tionship among the functions which constitute it, and that the attempt to separate the whole job into constituent functions serves to conceal that relationship which must be maintained in measuring fitness for work.[9]

The Wisconsin Miniature Test for Engine Lathe Aptitude, shown in Figure 24, is an example of the analogous test in miniature form. Here the attempt is to duplicate the part of an engine lathe which controls the movement of the cutting tool. The arm A supporting the point P is so mounted that the latter may be moved to any position on the vulcanite plate X, by the joint action of two screws placed at right angles to each other, and turned by the cranks H and H [1], which are exact duplicates to those actually used on an engine lathe. The subject's task is to move the point P around the series of 6 electric contacts shown in plate X, going as directly as possible from one to the other. A bell rings as each contact is touched to notify the subject that he has succeeded in touching it and as a signal for him to proceed to the next contact. In order to secure a record of the subject's movement in passing around the contacts, arm A is extended over area Y which holds a piece of paper. This extension holds a small lead pencil, P′, which traces a duplicate of the path made by point P.[10]

The miniature form of the analogous test has also been employed by the author in a device designed to measure perception of distance and speed of moving objects in the selection of motor vehicle operators.[11]

[9] W. Stern, "Richtlinien für die Methodik der psychologischen Praxis," *Beiheft. Z. ang. Psych.*, No. 29, Leipzig, 1921, p. 6 ff. (Also see this text, pages 164–65.)

[10] C. L. Hull, *op. cit.*, pp. 67–69.

[11] Although experimental studies with this test have been conducted in Milwaukee, Cleveland, and Philadelphia, the test has not yet been satisfactorily standardized. However, it will serve in further illustration of the type of test under discussion. (See Anon., "P. R. T. Improves Selection and Training Methods for Employes," *Elec. Rly. Jour.*, 23 (1928) p. 67. A modified form of this test has been used in the study of accident-prone drivers by the Cleveland Street Railway Co., described in Chapter XVIII, pp. 379–85.)

(Plate I.) The illustration of this test shows two tracks, on each of which is a miniature electric train. The train on one track is started by the examiner and passes around the track at speeds controlled by an automatic rheostat which varies the speed among "slow," "medium," and "fast" at periodic, irregularly spaced intervals. The train on the second track is under the control of the subject. The tracks are so laid that there are two points at which there is insufficient clearance for the trains. In addition, at one point on each track each train passes through a tunnel, so that speed of movement through blind areas must be estimated by the subject. The subject is instructed to keep the train under

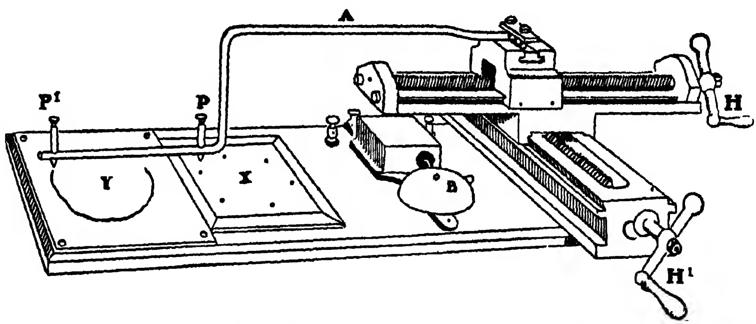


FIGURE 24. *Wisconsin Miniature Test for Engine Lathe Aptitude (After Hull)*

his control moving at as high a speed as possible and, at the same time, (1) to avoid collisions at intersections and non-clearance points, and (2) to avoid derailments because of excessive speed at curves. The number of trips around the tracks is automatically recorded and collisions and derailments are counted by the observer.

The test devised by the author in the selection of street car motormen (Plate I, Viteles Motorman Selection Test),[12] is an example of the analogous type of test which simulates, without duplicating, the operations of the job. The test, which is described in somewhat greater detail on pages 292–94, is constructed so as to involve a combination of attention and reaction similar to that required in the daily operation of the street car. No attempt is made to measure "attention," "selective response," "time of response," etc. separately. The test attempts to tap the combination of these functions as they are related on the job itself.

The outstanding feature of this test is that the applicant employs in reacting approximately the same set of muscles that are used in actual street car operation *without duplicating the responses used in operating the car*. The latter feature makes it possible to avoid the ef-

[12] M. S. Viteles, "Research in the Selection of Motormen," *J. Pers. Res.*, 4 (1925), pp. 173–199.

fects of training in street car operation upon test performance in the examination both of applicants, for purposes of hiring, and of trained men in the service of the company who have been involved in accidents. One of the chief features of the analogous test, whether in miniature or in another form, is that no identification of underlying abilities is necessary.

3. The third type of test is the *work sample,* which requires the subject to perform either all the operations of the job or certain selected operations as they are carried through under normal conditions in the plant. The work sample, although involving the activities of the job, differs from the trade test in the sense that the applicant, at the time of testing, is expected to possess none of the skills of the job. The criteria for selection when the work sample is used are the rate and amount of improvement of the subject with a given amount of practice. In other words, the work sample is a direct measure of the *trainability* or *educability* of the applicant for employment on the operations which he will be expected to perform after a suitable amount of training and experience on the job. The chief purpose in using the work sample is to plot a *practice* or *learning curve* and from the first part of the learning curve to predict the success of the worker after longer periods of practice on the job.[13] An incidental advantage of the work sample test, which naturally stretches over a comparatively long period of time, is that it affords an opportunity for an extended observation of the subject with respect not only to competency, but with reference to the play of the entire personality at work. This advantage has been particularly stressed by Poppelreuter,[14] Giese,[15] and others who recommend the use of this type of test. Examples of ths type of testing will be discussed in Chapters XIII and XIV.

From this discussion of types of tests it is evident that there are not only three types of tests, but two methods of testing, depending in part upon the type of test employed. The first involves a direct measure of competency by means of tests of short duration. The second involves primarily an analysis of learning curves, obtained through practice, combined with an extended observation of reactions.

FACTORS IN THE SELECTION OF TYPES OF TESTS

The choice of the type of test to be employed in selection for a particular job will depend in part upon the nature of the working situation

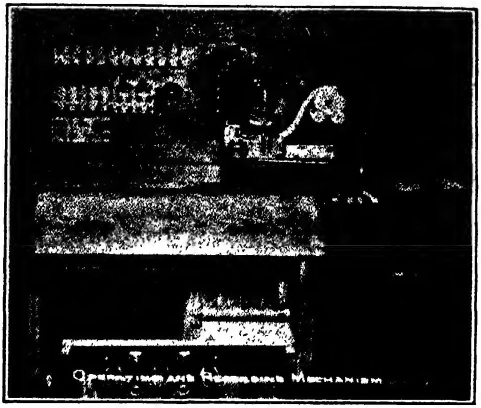
[13] See Chapters XIX and XX. In some instances, an analogous type of test will be used instead of the work sample itself as an agency for practice or in plotting the learning curve, but, in general, investigators who employ this type of test prefer a sample of the job as the operation to be practised.

[14] W. Poppelreuter, "Die Arbeitskurve in der Eignungsprüfung," *Ind. Psychot.*, 3 (1926), pp. 161–67.

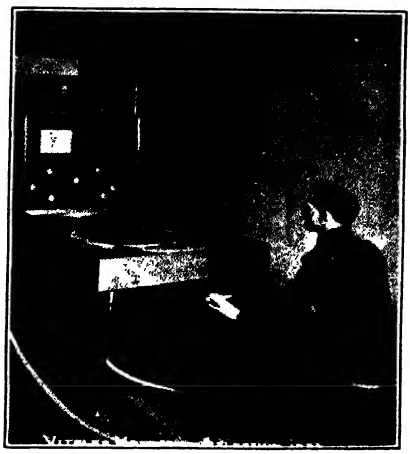
[15] F. Giese, "Die Arbeitsproben in der Psychotechnik," *Z. ang. Psych.*, 23 (1924), pp. 12–87.

Plate I

VITELES MOTORMAN SELECTION TEST



1.—Operating and Recording Mechanism



2.—The Test in Operation

3.—Speed and Distance Test

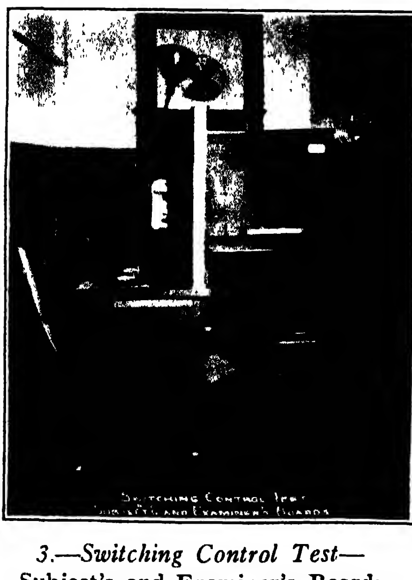
Plate II

TESTS USED IN THE SELECTION OF ELECTRICAL SUBSTATION OPERATORS

Philadelphia Electric Company

1.—Typical A. C. Substation Switchboard

2.—Directions Test



3.—Switching Control Test—
Subject's and Examiner's Boards

4.—Switching Control Test-
Examiner's Board

and in part upon the investigator's viewpoint with respect to (1) *the nature of ability* and (2) *the problem of educability.* Although general aspects of these problems have been treated in the discussion of the nature and origin of individual differences (Chapters VI and VII) and in relation to the measurement of general intelligence (Chapter VIII), it seems desirable to consider them again with reference to the specific question of the type of test to be used in measuring special abilities. The significance of the investigator's position on the *nature of ability* and of *educability* can perhaps best be illustrated by considering the prediction of success in jobs involving motor skill, i. e., in so-called "manipulative," "mechanical," or "manual" work.

Motor skill represents an integration of responses involving a variety of co-ordinated body movements organized into a kind of rhythmic pattern. Skill develops with practice, but its development depends partly upon the existence of certain inherent mechanisms of motor response which have been variously designated as *motor capacities, mechanical abilities, manual ability, practical ability,* etc.[16] For the purposes of this discussion the term *mechanical ability* or *abilities* will be used in referring to the underlying factor or factors in the development of motor skill. The problem in selection is that of measuring the underlying ability (or abilities) and predicting the level of skill which can be attained after a given amount of practice. The procedures employed in measurement and prediction will depend upon the answers that are given to such questions as:

Is motor skill determined by a single, central factor that may be designated as mechanical ability?

Does it represent an ensemble of elementary functions united to constitute a "gestalt" or "pattern," structurally self-contained?

What is the relative influence of practice and personal aptitude in the constitution of skill?

To what extent can the underlying mechanisms of skill be improved by training? [17]

One group of such questions concerns the nature of mechanical ability. Results of independent investigations have led to marked differences of opinion with respect to this problem.

1. According to one point of view, there is a single central factor—*mechanical ability*—common to all kinds of manipulative operations. The individual possessing a high degree of this common factor has the necessary equipment for success in any or all of the mechanical occupations. In other words, he has the qualifications for becoming a good carpenter, a good tool maker, a good sheet metal worker, a plumber—a satisfactory worker in all occupations in which integrated, co-ordinated body movements are of importance.

[16] See Footnote 18, The Nature of Skill, page 120.

[17] A. Gemelli, "Recherches sur la Nature de l'Habileté manuelle," *J. de Psych.*, 25 (1929), pp. 164–165.

This point of view is essentially that supported by Stenquist,[18] who gave several hundred boys in a New York City Public School a series of "intelligence" and "mechanical" tests. The latter included two assembling tests [19] and two picture tests. Each of the former required the subject to assemble as quickly as possible 10 common objects, such as a cupboard catch, clothes pin, etc. In the picture tests the subjects were required to match pictures of parts of mechanical objects and to answer questions concerning the parts of machines.

The fact that mechanical tests inter-correlated, "on an average, between .6 and .7," and that "one test of actual manipulation of objects, such as Series I, correlates about as high with either of the picture tests as it does with a second series of models to assemble," led Stenquist to conclude that "on the whole, any one of the four tests affords an important indication of a general ability that may for convenience be called general mechanical aptitude—*general in the sense that it does not pertain to any special trade, and mechanical, as is more or less obvious from its nature.*" [20] Mechanical ability, in other words, is conceived as a central factor resembling in the field of manipulation the factor of general intelligence, or "g," which, according to Spearman,[21] runs through all kinds of intellectual activities.

The concept of a central factor receives further support in a recent study by Cox,[22] who gave a series of tests not involving manipulation but requiring the solution of mechanical problems embodied in mechanical models, diagrams, etc., to 114 elementary school boys, 85 commercial students, and 228 Army mechanics. The results, according to the author, point to the existence of a central factor appearing in operations in which the subject is called upon to deal mentally with mechanical movements. This is a unitary mental factor "m" operating almost always in conjunction with "g" and forming part of what has been called "mechanical ability." Concrete mechanical ability, according to Cox, can be resolved into (1) the general factor "g," (2) the characteristic group factor "m," and (3) one or more factors specific to the mechanical task in question. Although Cox defines "m" as a group factor, its presence in a very wide variety of mechanical tasks stamps it as a central factor which determines success in manipulative tasks. From the viewpoint of content the "mechanical ability" of Cox is distinctively different from that of Stenquist, but the practical implications of both are essentially alike.

2. In contrast to the emphasis on a central factor is the opinion that

[18] J. L. Stenquist, *Measurements of Mechanical Ability*, Columbia University Contributions to Education, No. 130, New York, 1923, pp. 101.

[19] The Minnesota Assembly Box, shown in Plate III, is a revision of the Stenquist Mechanical Assembly test.

[20] J. L. Stenquist, "The Case for the Low I. Q.," *J. Educ. Res.*, 4 (1921), pp. 241–54.

[21] For the general background of this discussion of *specific, general,* and *group* factors see Chapter VIII, pages 127–33, and the references cited therein.

[22] J. W. Cox, *Mechanical Aptitude*, London, 1928, pp. 209.

there are many mechanical abilities so specific in character that a man may have the qualifications necessary for becoming a good punch press operator, but may lack those necessary for assembly work or for accuracy in hammering, filing, and in other types of mechanical work. That motor abilities are highly specific is the conclusion reached by Perrin [23] on the basis of an intensive study of 51 undergraduates at the University of Texas, involving the use of complex motor tests, a series of simple motor tests, an intelligence test, university grades, and character estimates. This conclusion is based largely on the values of intercorrelations among 3 complex and 14 simple motor tests shown in Table 23.

Perrin's findings and conclusions are confirmed in an investigation by Muscio,[24] who employed similar tests in examining 5 groups of 88 subjects, including boys and girls attending the elementary schools, Cambridge undergraduates, and women medical students. The consistently low value of coefficients of correlation among the tests leads Muscio to conclude that there is no "motor type" and that a person's relative performance in any one motor test does not normally represent a *general* motor test performance level, that is, a relative performance level which will be attained in any other motor test.

More recently Seashore [25] has employed a battery of tests known as the *Stanford Motor Skills Unit* in the investigation of mechanical ability. This includes: the *Koerth Pursuit Rotor,* for measuring *eye-hand co-ordination* in following a target moving in a circular path at high speed; the *Miles Motility Rotor,* used in testing *speed* in turning a small hand drill; the *Brown Spool-Packer,* involving *speed* in bi-manual co-ordination; the *Motor Rhythm Test,* measuring *precision* in following a regular rhythmic pattern on a telegraph key; the *Serial Discrimeter,* testing speed of finger movements in discriminative reaction to a visual series; and the *Tapping Key,* used in examining speed of forearm and finger movement on a telegraph key. A number of independent investigations with these and other tests has led to the conclusion that "the independence of the skills measured in these tests argues against any theory of general motor ability and in favor of specific skills. The independence of these performances as measured suggests that, if there are basic motor capacities, they are more numerous and more specific than previously believed." [26]

3. A position intermediate between that of insistence upon a central, common factor or upon the absolute specificity of factors in determining manipulative skill is adopted by those who argue for the existence of distinct abilities each of which, however, functions in a variety of

[23] F. Perrin, "An Experimental Study of Motor Ability," *J. Exp. Psych.,* 4 (1921), pp. 24–56.

[24] B. Muscio, "Motor Capacity with Special Reference to Vocational Guidance," *Brit. J. Psych.,* 13 (1922), pp. 157–184.

[25] R. H. Seashore, "Stanford Motor Skills Unit," *Psych. Monog.,* 39 (1928), pp. 51–65.

[26] R. H. Seashore, "Individual Differences in Motor Skills," *J. Gen. Psych.,* 3 (1930), p. 61.

related mechanical skills. This point of view denies the existence of a single, central factor, but assumes that there is a restricted number of *group* factors appearing in different combinations in diverse mechanical tasks. Certain of these abilities may be somewhat generalized in character, in the sense that they appear in a wide variety of mechanical tasks while others may be somewhat more specialized, although still extending over a distinctive number of tasks.

TABLE 23[27]

Showing Correlations Among Various Motor Tests (After Perrin)

"COMPLEX" MOTOR TESTS	BOGARDUS r	CARD SORTING r	CO-ORDINATION r
1. Bogardus			— .10
2. Card Sorting	— .06		+ .36
"SIMPLE" MOTOR TESTS			
1. Reaction time	+ .16	+ .21	— .06
2. Inhibition of winking reflex ..	+ .02	— .11	+ .02
3. Motor memory	+ .02	+ .22	+ .17
4. Weight discrimination	— .07	— .03	— .01
5. Aiming	+ .24	— .09	+ .12
6. Aiming (blindfolded)	+ .29	+ .05	+ .04
7. Balancing	+ .38	— .06	— .11
8. Rhythm (pendulum)	+ .17	+ .20	+ .29
9. Rhythm (kymograph)	— .02	+ .12	+ .12
10. Tapping	+ .22	+ .02	+ .01
11. Steadiness	+ .09	— .04	+ .01
12. Tracing	— .11	— .01	+ .09
13. Dynamometer	— .22	+ .20	+ .39
14. Vital capacity	— .14	+ .09	+ .22

(From Hull)

This is essentially the position adopted by Farmer, who applied three tests of *aestheto-kinetic co-ordination,* including a *Choice Reaction Test,* the *McDougall-Schuster Dotting Test,* and a *Purusit Meter,* to one group of 645 subjects and to another of 449 subjects. Farmer uses the term aestheto-kinetic to avoid employing the word "motor" or "mechanical," but describes these tests as having the common characteristic that "afferent impulses received through the sensory organs have to be interpreted as signs for the performance of certain rapid, accurate movements by hand or foot." [28] Although the intercorrelation

[27] C. Hull, *Aptitude Testing,* Yonkers, N. Y., 1928, p. 211.

[28] E. Farmer, "A Group Factor in Sensory Motor Tests," *Brit. J. Psych.,* 1927, p. 328. (Also see E. Farmer and E. G. Chambers, "A Psychological Study of Individual Differences in Accident Rates," *Ind. Fat. Res. Bd., Rep.,* No. 38, (1926), pp. 46.)

among these tests is only + 0.25, the consistency between intercorrelations in various groups, as well as the value of this coefficient, are interpreted as pointing to the existence of a group factor which characterizes more complex forms of motor response. This common element is not so marked as that which connects intelligence tests, but it is due neither to intelligence nor to strength since there is no correlation between these factors and the aestheto-kinetic tests.

The existence of a group factor in aestheto-kinetic response is explained on theoretical grounds by Farmer who points out that "this degree of intercorrelation is intermediate between that of motor tests in general, which do not intercorrelate at all, and intelligence tests which intercorrelate highly. Co-ordinated movement requiring conscious direction is biologically intermediate between the ability merely to move and the ability to think. This same order is observed in the effects of an anaesthetic. First the higher centres of thought are affected, then highly co-ordinated movements such as balance and walking, and finally any movements at all, the pure reflex movements being affected last. The process of anaesthetizing proceeds backwards through our biological history and attacks first the functions that have high intercorrelations, next those which have small intercorrelations and finally those which have no intercorrelations. This parallelism between the magnitude of the average intercorrelation coefficients and the biological level of the functions from which they are obtained is curious, and if it ultimately turned out to be a true relationship, it might lead to a useful classification of psychological tests." [29]

Evidence of the existence of group factors is also found in an investigation by Earle, Gaw, and others,[30] involving the examination of approximately 1000 children between the ages of 12 and 17, on a series of 15 tests including peg boards, disc placing, aiming, threading beads, tactual discrimination, discrimination of parallel lines, etc. The study of intercorrelations brings out a high degree of independence of abilities measured by the tests. When Spearman's statistical criteria are applied to the table of correlations the factors determining success in each test appear to be specific to the test situation. Although tetrad differences cluster around zero, the intercorrelations among tests appear too low to justify the hypothesis of a central factor. Of 288 coefficients, only 228 are greater than .20. However, the fact that tests may be grouped to show higher correlations between themselves than with those in other groups may be taken, according to the authors, to signify the presence rather than the absence of group factors. Tests of dexterity, for example, have an average intercorrelation of + 0.36; tests involving speed, + 0.29. However, tests of speed show an average intercorrela-

[29] *Ibid.*, p. 330.

[30] F. M. Earle, F. Gaw and others, "The Measurement of Manual Dexterities," *Nat'l Ins. Ind. Psych., Report* No. 4, 1930, pp. 88. (See also F. M. Earle and A. Macrae, "Tests of Mechanical Ability," *Nat'l Ins. Ind. Psych., Report* No. 3, 1930, pp. 42.)

tion with those of dexterity of only + 0.13. "Although no *general* factor of 'manual dexterity' is discoverable, the existence of *group* factors—common to, and influencing success in, *certain* tests"—is therefore, according to Myers (who writes the preface to this study), "by no means excluded. Indeed their presence is, even if only in a small degree, suggested by the finding that increase in age is accompanied by increase in ability in those tests of manual dexterity in which *speed* of movement predominates. Group factors may also account for the finding that training for certain trades may lead to increased proficiency in certain tests." [81]

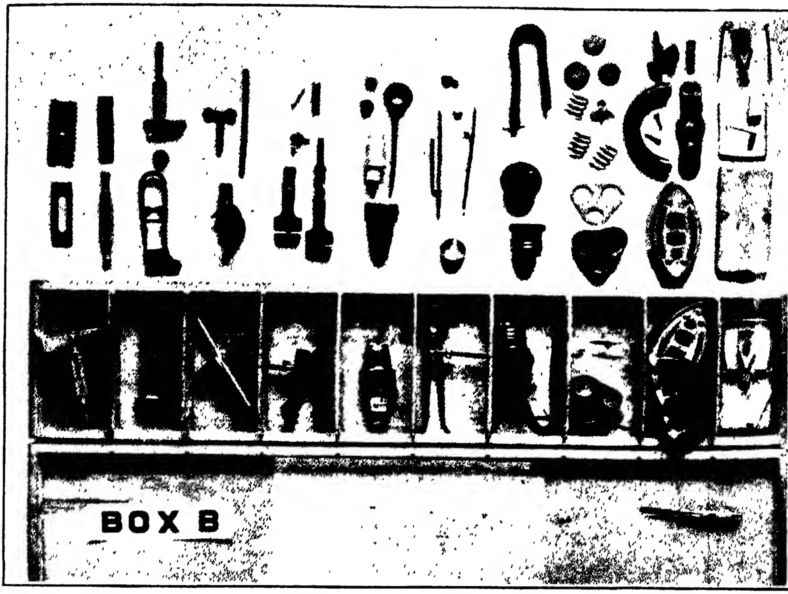
Additional evidence on the existence of group factors as the determiners of mechanical ability appears in a recent study by a group of investigators [82] at the University of Minnesota who undertook to investigate the questions of whether it is possible for an individual to be distinctly gifted in one line of mechanical work and to possess poor or mediocre capacity in another, or whether there is a single general motor ability that enables its possessor to do all kinds of mechanical work well. The investigators started by choosing, and trying out on a group of 217 junior high school boys, a battery of tests sufficiently promising to warrant consideration as possible measures of mechanical ability. After reviewing these tests—in order to make instructions simpler and more specific, to make administration uniform and useful, to improve the tests in reliability and validity—a battery of tests was selected and given to a main experimental group of 150 junior high school boys whose course included shop work. This battery included the *Minnesota Assembly Tests* (after Stenquist), (Plate III); *Minnesota Spatial Relations Test* (after Link), (Plate III); *Minnesota Paper Form Board Tests* (after Army Beta); *Card Sorting Test* (Plate III); *Packing Blocks Test* (Plate III); *Nine-Hole Steadiness Test; Stenquist Mechanical Aptitude, Picture Tests I and II.*

The investigation also included a study of academic success, previous experience in mechanical work, measurement of mechanical interest, an examination of home influence in relation to the genesis of mechanical ability, etc., which will not be considered here.[83] In the attempt to develop satisfactory criteria of proficiency three types of material were employed: (1) finished products made by boys in introductory courses in shop work in the junior high school, (2) results of final operations tests given in the same courses, and (3) the results of objective information tests given in the same courses.[84] Accurate measures of *quality* and *quantity* of work were obtained by means of objective rating devices involving a measurement of certain specified characteristics of each project, including a grand total of 393 points.

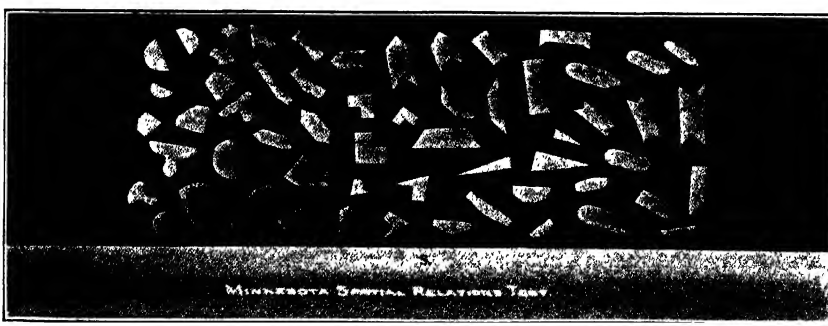
[81] *Ibid.*, p. 1.
[82] D. G. Paterson, R. M. Elliott, L. D. Anderson, H. A. Toops, E. Heidbreder, *Minnesota Mechanical Ability Tests*, Minneapolis, 1930, pp. 586.
[83] See Chapter VIII, pages 132–33.
[84] D. G. Paterson, R. M. Elliott, L. D. Anderson, H. A. Toops, E. Heidbreder, *op. cit.*, pp. 199–201.

Plate III

MINNESOTA MECHANICAL ABILITY TESTS



1.—*Minnesota Assembly Test*



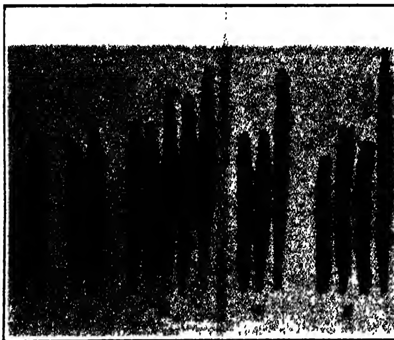
2.—*Minnesota Spatial Relations Test*

3.—*Card Sorting Test*

4.—*Packing Blocks Test*

Plate IV

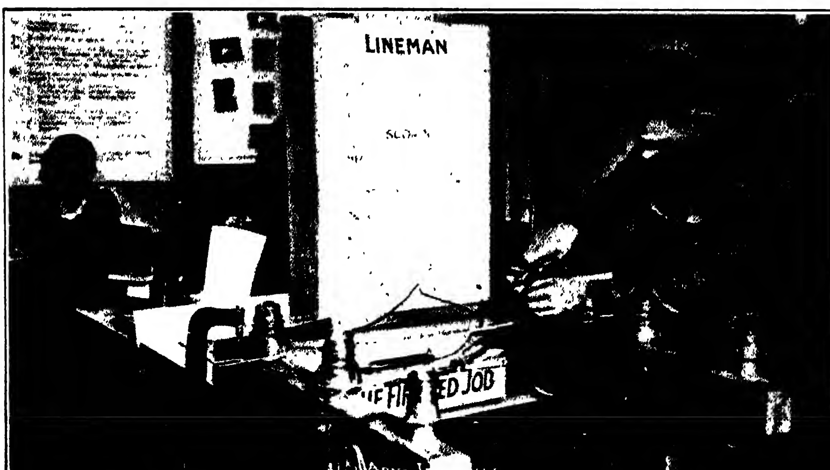
APPRENTICE SELECTION TESTS



1.—*Smithing Test (after Heilandt)*

2.—*Manual Control (after Rupp)*

TRADE TEST FOR LINEMAN



Three criteria were established: *quality*, *information*, and *quantity-quality*. The low correlations between tests and the latter criteria; the high correlation between the information criteria and intelligence; combined with the preponderant interest in mechanical ability as manipulation, led to the selection of the latter in the construction of teams of tests for optimal prediction. The highest validity coefficient between any battery of tests and any criterion (combined quality and information criterion) was + 0.81. A number of batteries of tests suited for different purposes were developed, having validity coefficients from + 0.55 to + 0.73, most of them over + 0.60, with reliability coefficients between + 0.86 and + 0.94.

The chief item of interest for the moment is the treatment of results by the investigators to determine the nature of mechanical ability.[35] The application of statistical methods devised by Spearman indicates that mechanical ability probably does not involve any single general factor. Low intercorrelations between different measures of mechanical ability suggests that specific factors play the major rôle.[36] Further analysis suggests that *quasi-general* or *group* factors may play a part in determining proficiency in manipulation as defined by the criterion, although the data give no indication of the concrete content or nature of these group factors.[37]

4. The fourth point of view lays stress upon the *functional relationships* in motor skill. This outlook reflects the influence of the gestalt school in psychology, which centers attention upon the pattern of an activity rather than upon its constituent parts.[38] In the traditional, analytic approach in psychology, an act of skill and—as a matter of fact, personality itself—is viewed as a *mosaic* of simpler elements which can be isolated and submitted to microscopic examination.[39] The difference between two acts of skill, such as drill press and automatic screw machine operation, lies only in the kind or quantity of traits involved,[40] and the mechanical ability (or abilities) underlying them can be distinguished as stable and unchangeable factors in the mixture if only suitable situations can be designed and if agreement can be reached upon the adequacy of statistical methods for isolating them. The contrasting opinion is that every skilled act is an integrated whole—a dynamic functional pattern which becomes completely modified in structure if any change is made in the subordinate, interrelated parts. Such, for exam-

[35] For a comparison and critical discussion of the techniques, findings, and conclusions of the studies by Cox and by the Minnesota groups, see O. L. Harvey, "'Mechanical Aptitude' or 'Mechanical Ability'?—A Study in Method," *J. Ed. Psych.*, *22* (1931), pp. 517–522.

[36] D G. Paterson, R. M. Elliott, L. D. Anderson, H. A. Toops, E. Heidbreder, *op. cit.*, p. 300.

[37] *Ibid.*, p. 231.

[38] W. Koehler, *Gestalt Psychology*, New York, 1929, pp. 403.

[39] See A. Juhasz, "Die 'Krise' der Psychotechnik," *Z. ang. Psych.*, 33 (1929), pp. 456–464; M. S. Viteles, "Die 'Gestalt' Betrachtungsweise in der angewandten Psychologie," *Z. ang. Psych.*, 36 (1930), pp. 525–531.

[40] The possibility of isolating constituent parts of an act of skill is, for example, assumed in the technique for skill analysis employed by Fairchild, described in Chapter IX.

ple, is the conclusion reached by Leurquin,[41] following an analysis of the performance of 150 subjects on 5 motor tests, including a few of the Link tests, the tremometer, and a tapping test. Schultz,[42] Baurmann,[43] and other German investigators have likewise pointed to the disappearance of the unique quality of a mechanical activity when the attempt is made to break it up into constituent elements.

1. The practical outcome of the conclusion that mechanical abilities are highly specific in character is that every job will require specific vocational tests of just those abilities that function in the job. The only satisfactory procedure would necessarily involve a "sampling of serial performances of the same general neuro-muscular co-ordinations" [44] as are used on the job—in other words, the use of *analogous tests* duplicating or simulating the operations of the job. As a matter of fact, as Hull has pointed out, pressed to its logical conclusion, the specific theory would permit testing only by means of *work samples,* since factors determining success in two diverse activities—the test and the job—could not be common to both.[45]

2. If mechanical ability is general in character, in the sense that there is a central factor common to all manipulative operations, one battery of tests will suffice to measure mechanical ability for a great variety, if not all, manipulative tasks. The tests will necessarily have to be *analytic* in character, since no battery could be analogous to a great variety of manual jobs.

3. If there exists a restricted number of group factors, combined in different degrees and in different relationships in a variety of tasks, it again becomes desirable to use the *analytic* type of test. The problem here is that of selecting a battery of tests tapping all of the important group determiners in manipulative work and to combine them, by means of different weights, in selection for a variety of jobs.

4. If an unmodified gestalt viewpoint is adopted in mental testing—with an emphasis upon functional relations rather than upon constituent units—it again becomes necessary to use either the *work sample* or possibly an *analogous* test resembling very closely the related motor operations of a job as a means of predicting achievement on it.

On "Educability"

The choice of tests to be used in measuring vocational fitness is also determined by the investigator's viewpoint on the influence of practice

[41] R. Leurquin, "Étude experimentale sur l'habileté motrice," *L'Année Psych.*, 30 (1929), pp. 106–43.

[42] J. H. Schultz, "L'Orientation professionnelle en Allemagne," *Rev. de la Sci. du Trav.*, 1 (1929), pp. 85–107.

[43] H. Baurmann, "Ein Beitrag zur Frage der individuellen Verschiedenheiten im Bedienen von Werkzeug-maschinen," *Psychot. Z.*, 3 (1928), pp. 81–99.

[44] R. H. Seashore, "Individual Differences in Motor Skills," *op. cit.*, p. 63.

[45] C. L. Hull, *op. cit.*, p. 201.

in modifying and improving inherent ability.[46] The problem, in so far as use of tests in selection is concerned, has been well stated by Claparède, who points out that it has been assumed, by implication at least, that if an individual, A, exhibits an aptitude superior to B (on any type of test), he is also more capable of developing that aptitude by practice. In other words, the trainability (or educability) of an aptitude is supposed to be a sort of attribute of the aptitude and dependent upon its degree or quantity.[47] The use of scores obtained in the single application of a test—either of the analytic or analogous type—assumes that those "persons who make the highest scores will, on the whole, retain their high position after training." [48]

In contrast with this are the possibilities (1) that the plasticity of the psychophysical apparatus, with respect to any activity, is an independent trait of the individual,[49] or (2) that, on the whole, individuals who are inferior in any ability will profit more from training than those who are superior and will, as the result of practice, reach the same level of proficiency as the latter. The latter situation would make it necessary to observe progress with practice, as recorded in *learning curves,* as the sole criterion in selection.

In so far as mechanical ability is concerned, the point of view that practice favors increasing uniformity has been warmly defended by a number of European investigators. Among these is Argelander,[50] who studied the effect of training upon 6 subjects employing the index finger of one hand in typing. This, of course, restricted the typing to small letters, since the shift key could not be used. The results show a growing convergence of learning curves resulting from a greater improvement of those starting with low scores as compared with those starting with higher scores. Similar results in the case of typing are reported by Bieneman [51] and by Chapman.[52] In the case of the latter the improvement in speed of typing words after 20 hours of practice by the 6 worst subjects amounts to 374 per cent in contrast to the improvement of 205 per cent on the part of the 6 subjects whose results were best at the beginning of the experiment.

In a later study by Argelander [53] 118 apprentices were required to prepare 5 pieces of work. The apprentices were classified into 3 groups

[46] This problem has been treated in general terms in Chapter VII, on the "Origin of Individual Differences."

[47] E. Claparède, *L'Oriëntation professionnelle,* Geneva, 1922, p. 73.

[48] C. S. Myers, *On Educability,* V-e Conference Internationale de Psychotechnique, Utrecht, 1928, p. 104.

[49] F. L. Wells, "The Relation of Practice to Individual Differences," *Am. J. Psych.,* 23 (1912), pp. 75–88.

[50] A. Argelander, "Beitrage Zur Psychologie der Übung," *Z. ang. Psych.,* 19 (1921), pp. 1–38; also *Z. ang. Psych.* 21 (1923), pp. 225–58.

[51] D. Beineman, *Recherches sur l'aptitude dactylographique en vue de l'orientation professionnelle,* Bur. Intern. de Trav., Geneva, 1923, pp. 47.

[52] J. C. Chapman, "The Learning Curve in Typewriting," *Am. J. Psych.,* 3 (1919), pp. 252 ff.

[53] A. Argelander, "Zur Frage der Übungsfahigkeit," *Psychot. Z.,* 3 (1928), pp. 142–147.

—good (39 cases), average (40 cases) and poor (39 cases)—on the basis of speed on the first work problem. Comparisons made after a lapse of 5 months revealed a levelling of attainment among the 3 groups. Of the 39 apprentices who were classified as good (from the viewpoint of speed) on the first task, 18 per cent showed a marked increase in speed with practice and 64 per cent a small increase. Of the 39 apprentices rated as poor or slow at the beginning, 62 per cent showed a marked increase in speed and 10 per cent a restricted improvement in speed of output. Moreover, certain ones of the latter group actually surpassed the former at the close of the experiment. These findings are supported by results in investigations conducted by Roëls and van Wijk, [54] Ehinger,[55] and others.

The analysis of the suitability of each type of test—and each method of testing—involves a comparison of these various techniques in the same working situation. A few studies of this kind have been made. Among them is an investigation by Gemelli, who bases a preference for the *analogous test* and *work samples* on experimental findings obtained in a study involving 35 spinners whose duties consisted of twisting cotton into a thread, inserting it into a spindle, watching for broken threads, and renewing empty bobbins and full spindles.[56] A series of 12 analytic tests, including the *Moede Impulsimeter*, *Whipple Steadiness Test*, *Tapping Test*, *Bead Threading*, test of *Reaction Time*, etc. were given to the workers and results compared with daily production. Coefficients range from + 0.07 (Dynamometer) to + 0.35 (Reaction Time) with a median of + 0.16. The workers were then given a series of 4 analogous tests. On one test each of 20 threads arranged on a board had to be passed through a ring and round 2 hooks. On the second the subject was required to pass 2 threads through a hook and to knot them. On the third test the subject was required to find and repair hanks of wool, one in every 10 hanks presented being broken. On the fourth the subject had to watch 20 rotating bobbins and, whenever one stopped, to find the cause of stoppage—broken thread, empty bobbin, etc. Correlations between scores on these tests and production were (1) + 0.71, (2) + 0.68, (3) + 0.85, and (4) + 0.90. From these results the author concludes that analogous tests are more suitable than analytic tests for measuring aptitude for industrial occupations.

Unfortunately there are a number of weaknesses in technique which detract from the value of these findings. The analytic tests used in the study were chosen haphazardly—merely because they happen to be

[54] F. Roëls and J. van Wijk, *De invloed der oefening op de oorspronkelijke individueele verschillen im arbeidspretaties*, Mededeelingen uit het psychologisch laboratorium der Rijksuniversiteit te Utrecht, 1 (1924), pp. 65 ff.

[55] G. Ehinger, "Recherches sur la développement de l'habileté manuelle par la pratique d' un metier manuelle," *Ar. de Ps.*, 80 (1927), pp. 299–317.

[56] A. Gemelli, "Recherches sur le diagnostic de l'habileté motrice," *Rev. de la Sci. du Trav.*, 1 (1929), pp. 181–196.

tests which have been frequently employed in investigations of motor skill. No attempt was made to weight individual tests, or to determine the value of the entire battery—or of teams of tests—in predicting performance on the job. Moreover, a subsequent investigation of "lasters" in the shoe industry shows higher correlation between the same tests and proficiency (Range + .02 to + 0.39; Median + 0.26) than appears in the case of spinners. From these results, it is true, Gemelli concludes that analytic tests—selected with due respect for the activities of the job—may be useful in selection, but when the choice is between analytic and analogous the latter type is favored.

As part of the same investigation Gemelli compared the quantity and quality of output (as determined from plant records) of 10 "lasters" at the end of 8 days, 1 month, and 6 months of employment. The results, given in Table 24, show progressively increasing coefficients with increasing length of service. The investigator also reports a tendency on the part of apprentices to reach the same level of production with training.[57] From these results Gemelli concludes that the analysis of records obtained during the early period of apprenticeship —in other words, the examination of the learning curves—represents a sound method of selection which can be applied with smaller probability of error than appears when "aptitude tests" are used.[58]

In considering Gemelli's results and conclusions, it is interesting to note that neither production records for 8 days nor those for 1 month give satisfactory prediction for quantity and quality of output after 6 months of service. Significant correlations are obtained only when output for 3 months is compared with that of 6 months. Assuming the absence of technical defects in the experiment, it is questionable whether it is economical and practicable for industry to employ a method of selection involving a 3 months' probationary period as a method of selection for semi-skilled jobs. The probable increased cost of turnover, spoiled work, etc., entailed in the use of such a selection method points to the desirability of more intensive research on analytic and analogous types of test which can be given in relatively short periods of time.

The need of further investigation of this kind is also evident from an examination of findings cited in Chapter VII, and from evidence presented by other investigators such as Hildebrandt,[59] Eschowitz,[60]

[57] Approximation of the same level of production after a period in the plant by workers who start at different levels is no *sure* sign of convergence of ability because of the possible influence of restriction of output by workers with superior ability. These frequently keep output at a lower level, i. e., at the level of the average worker, to avoid reduction in rates. For this reason many of the coefficients of correlation between production during early and later periods of employment are *spurious*. See discussion of restriction in output in Chapter XXV, and on incentives in learning, Chapter XX, pages 401–07.

[58] A. Gemelli, *op. cit.*, p. 196.

[59] H. Hildebrandt, "Übung und Eignungsprüfung," *Ind. Psychot.*, 3 (1926), pp. 96–109.

[60] N. Eschowitz, "Zur Frage der Bewährung von Handgeschicklichkeitsproben," *Psychot. Z.*, 2 (1927), pp. 23–26.

and Kellner[61] pointing to the absence of converging levels of performance with practice in tasks involving manual ability. The latter has required a group of workers to reproduce at periodic intervals a series of standard work projects involving filing, etc. The workers were classified into 3 groups, good, average, and poor, on the basis of first performance, and the results of each of these 3 groups plotted separately upon the repetition of each task over a period of years. The results of this study are illustrated in Figure 25, showing the time and number of errors on the filing project for each of the 3 groups. It is evident that both the time required to complete the project and the number of errors decrease with practice in the case of each of the 3 groups. However, each group maintains its own level and at the end of the sixth repetition and at the close of a 3½ year period there is still no indication of a tendency toward convergence on the part of the 3 groups.[62]

TABLE 24

Comparison of Quality and Quantity of Output of Ten "Lasters"
(After Gemelli)

	1	2	3	4	5	6	7	8	9	10
Correlation between output after 8 days and after 6 months	.23 (0.11)	.12 (0.19)	.17 (0.09)	.11 (0.06)	.07 (0.14)	.25 (0.15)	.31 (0.09)	.12 (0.09)	0.6 (0.11)	.21 (0.16)
Correlation between output after 1 month and after 6 months	.35 (0.12)	.31 (0.14)	.27 (0.07)	.29 (0.11)	.16 (0.11)	.28 (0.07)	.42 (0.07)	.34 (0.11)	.21 (0.11)	.25 (0.14)
Correlation between output after 3 months and after 6 months	.61 (0.09)	.57 (0.11)	.36 (0.07)	.43 (0.11)	.21 (0.13)	.66 (0.09)	.77 (0.07)	.62 (0.13)	.24 (0.11)	.53 (0.12)

* Figures in parentheses represent P. E.'s.

The problem of educability is complicated by the question of whether there is transfer of skill from one activity to another; by possible differences in the progress of learning in activities involving accuracy as compared with those involving speed; by the effect of the relative

[61] H. Kellner, "Neun Jahre Prüferfahrungen in der Berliner Metallindustrie," *Ind. Psychot.*, 5 (1928), pp. 46–47.

[62] The drop in time and increase in number of errors in October, 1923, is accounted for by the fact that the work project at the time of this particular examination was done under conditions different from those present at the time of the other examinations. The press of work at the time of the October, 1923, examination caused the supervisors to urge the workers to finish the task as quickly as possible. This resulted in a pronounced decrease in time but also brought about an increase in the number of errors.

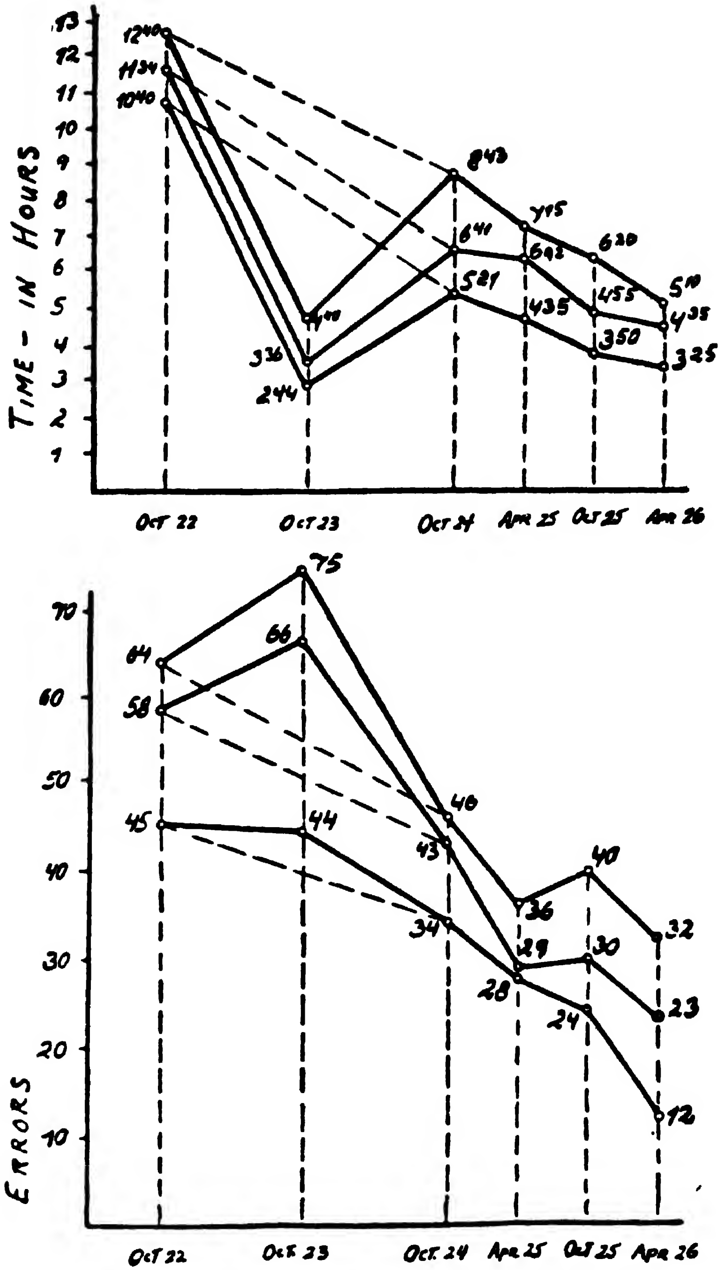


FIGURE 25. *Improvement with Practice on Filing Project (After Kellner)*

simplicity and complexity of the task; by difficulties in determining the exact amount of previous practice of each subject; etc.[63] It is possible, as Claparède [64] has pointed out, that the tests usually employed in selection will fall into different groups with respect to their relation to educability and their suitability for predicting status after training. Insofar as this is a problem, every test selected for use must be compared with performance at work over a long, as well as a short, period of time to determine its value in predicting success "in the long run."

It is also possible, as Kern [65] has recently suggested, that initial scores on tests of short duration lead to gross errors in the case of the *individual,* although generally satisfactory in selecting the *best* and eliminating the *worst,* in a group of applicants for employment. This is also essentially the viewpoint of Giese [66] and of Poppelreuter.[67] A testing instrument which only identifies the extremes of ability is unquestionably deficient from the viewpoint of the worker, regardless of its value to the employer. Such a deficiency, if it exists, makes it necessary to carry the testing operation—on a work sample, an analogous, or even an analytic test—beyond the beginning stage to that critical point in the learning curve where stability of performance is attained.[68] However, beyond all of these considerations remains the fact, appearing in the studies described in Chapters XIII to XV inclusive, that both analytic tests and analogous tests, used with only a single trial—either without or with fore-practice—have in many instances given eminently satisfactory results in fitting workers to jobs.

have been marked by considerable advance in the development of tests of temperament and character, there is still place for the warning voiced by Bingham concerning the use of the "new and promising facilities for measuring personality. Caution is needed for two reasons: the low reliability of the individual measures, and the great flexibility or modifiability of many personalities. Temperament and habitual emotional attitude differ in these regards from intelligence, which remains roughly constant with the passage of the years. The introvert cannot greatly alter his I. Q., but he sometimes outgrows his shyness, suppressions, his tendencies to reverie, his slowness to act. The extrovert may learn to meditate, to be more considerate, to check a natural abruptness to action." [70]

In general, at the moment, measures of temperament and character can probably serve better as a basis for the re-education of personality in the case of employees already in service than as a criterion in selection and placement. At the same time, it is highly probable that questionnaires and measures of the type represented by the *Thurstone Neurotic Inventory; Bernreuter Personality Inventory* (page 246); *the Colgate Personal Inventory;* the *Allport Ascendance-Submission Reaction Study* will find their place in determining adequacy of adjustment and in measuring special tendencies such as introversion-extroversion, ascendance-submission, in particular industrial situations. Attitude measures of the type recently developed by Thurstone [71] and Allport and Vernon [72] may be further useful in tapping the attitudes of employees and applicants toward personal, social, and economic issues.

There is further promise in the measurement of such qualities as industry, trustworthiness, punctuality, etc., in the finding by Hartshorne, May, and Shuttleworth that there is a *general integration* of character so organized that the individual with desirable qualities is, in general, *consistent,* whereas the one with undesirable qualities is generally inconsistent.[73] In other words, a man who is generally honest is consistently honest; that is to say, dependably honest. The man who is generally dishonest is inconsistent; he may be honest in one situation and dishonest in another. The man with good character acts uniformly and consistently with regard to commendable things. The man with low character is more a creature of chance and impulse blown about by every change of circumstance. This means that the determination that a man's character is high is valuable, for since his conduct is consistent,

it is possible to predict with some degree of accuracy what he will do in specific situations. "A knowledge that a man's character is high would be of great importance in employing a bank teller, for it would be as good a guarantee as could be obtained that the person is *dependable* and tends to be more consistently honest, conscientious, thorough,

THE PERSONALITY INVENTORY

BY Robert G. Bernreuter

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The questions on this blank are intended to indicate your interests and attitudes. It is not an intelligence test, nor are there any right or wrong answers.

In front of each question you will find: "Yes No ?"

If your answer is "Yes," draw a circle around the "Yes." If your answer is "No," draw a circle around the "No." If you are entirely unable to answer either "Yes" or "No" to the question, then draw a circle around the question mark.

1.	Yes	No	?	Does it make you uncomfortable to be "different" or unconventional?
2.	Yes	No	?	Do you day-dream frequently?
3.	Yes	No	?	Do you usually work things out for yourself rather than get someone to show you?
4.	Yes	No	?	Have you ever crossed the street to avoid meeting some person?
5.	Yes	No	?	Can you stand criticism without feeling hurt?
6.	Yes	No	?	Do you ever give money to beggars?
7.	Yes	No	?	Do you prefer to associate with people who are younger than yourself?
8.	Yes	No	?	Do you often feel just miserable?
9.	Yes	No	?	Do you dislike finding your way about in strange places?
10.	Yes	No	?	Are you easily discouraged when the opinions of others differ from your own?
11.	Yes	No	?	Do you try to get your own way even if you have to fight for it?

accurate, and the like in most situations in which he finds himself than the average man. On the other hand, knowledge that a man's character is low tells us more than anything else that he is not dependable and that one can predict little about his conduct in specific situations. He might be honest, and he might not. Probably he would tend to adopt the group mores, but would yield somewhat readily to temptation." [74] However, although Hartshorne, May, and Shuttleworth propose two batteries of tests to be used in measuring such general integration of character, the standardization of such a battery is far from complete. Useful tools for the prediction of important character traits on the part of applicants for employment are still in a highly experimental stage.

[74] P. M. Symonds, *op. cit.*, p. 565.

The Measurement of Fear-Reaction

In individual instances the attempt has been made to devise objective tests for the measurement of a specific aspect of temperament and character of importance in a given job. The test employed by Snow [75] in measuring "fear-time-reaction" of taxicab drivers is an example of this kind. Tramm [76] has used frightening stimuli as part of a test for the selection of motormen. "To test how a candidate will behave in the event of a danger, whether he will lose his wits to the extent of letting go the controller handle and brake and passively stand by, or whether he will promptly take measures required for the safety of his car and passengers, the man is placed before a controller handle, and while he is practicing with it he is frightened by a sudden report, a short-circuit flash passing before his eyes or the floor yielding below his feet. If he loses his presence of mind in these circumstances, the company knows that he should not be intrusted with the care of a car. If, on the other hand, he promptly performs such manipulations as were recommended to him in the event of anything unforeseen happening before his eyes, he is considered to possess the presence of mind required for his responsible profession." [77]

Lahy [78] has employed the psychogalvonometer in measuring the "emotionality" of street car and bus operators. For the selection of substation operators the author [79] has devised a test of reaction to frightening stimuli—electric flash-over, smoke, loud noise, etc.—occurring in emergency situations in the substation (Plate II). This test measures the disturbance of accuracy in a simple psycho-motor response (that of following a pointer in an electrical pursuit meter) as a result of the frightening disturbance as well as accuracy and reaction time in switching at the moment of the disturbance.

The Observation of Reaction

Recent investigations lend support to the opinion that expert observation of the individual's performance on tests of competency is capable of supplying to the experienced observer much valuable information on the individual's temperamental traits.[80] Vernon,[81] for example, criticizes both the validity and apparent objectivity of questionnaires, rating scales, and the type of test represented by the

[75] A. J. Snow, *Psychology in Business Relations*, Chicago, 1925, pp. 524–550.

[76] K. A. Tramm, "Die Bewährung des psychotechnischen Prüfverfahren für Strassenbahnführer," *Ind. Psychot.*, 1 (1924), p. 36–42.

[77] A. Gradenowitz, "Psychological Tests for Motormen," *Elec. Rwy. J.*, 59 (1922), p. 144 ff.

[78] J. M. Lahy, *La Selection psychophysiologique des travailleurs*, Paris, 1927, pp. 117–129.

[79] M. S. Viteles, "The Human Factor in Substation Operation," *Pers. J.*, 8 (1929), pp. 81–113.

[80] C. Burt and others, "A Study in Vocational Guidance," *Ind. Fat. Res. Brd., Report.*, No. 23 (1926), pp. 57–72.

[81] P. E. Vernon, "Tests of Temperament and Personality," *Brit. J. Psych.*, 20 (1929), pp. 97–119.

Downey Will Temperament Test, and their neglect of qualitative aspects of performance as a clue to temperament and character. On the basis of an investigation involving observation of reactions of subjects engaged in taking a series of 11 tests, he concludes that such traits as the aesthetic tendencies of the individual, suggestibility, persistence, etc., can be accurately graded as a result of such observation. The application of this method, as has been pointed out by Fejgin-Garstenteyg,[82] involves a notation of all details of the subject's conduct by the examiner. From this the attempt is made not only to draw conclusions on the results of individual tests but to arrive at a picture of the personality trends of the individual as an organic unit. The importance of clinical observation of performance will be discussed again in the section of this chapter dealing with the administration of psychological tests.

The Measurement of Interest

Acceptance or rejection of the activities of the job and the feeling of pleasantness or unpleasantness aroused thereby represent important factors in vocational adjustment.[83] The most promising objective approach to the measurement of interests for purposes of selection appears to be in the use of interest inventories of the kind developed by the Carnegie group—including Moore, Miner, Ream, Freyd, and others —under the direction of C. S. Yoakum.[84] These find their latest expression in the general inventories standardized by Cowdery,[85] Strong,[86] and Manson.[87] (See illustration on page 250.) Cowdery's interest blank, for example, uses 263 items including 84 *occupations,* 78 *types of people,* 34 *sports and amusements,* 6 *kinds of pets,* 13 *kinds of readings,* 23 *miscellaneous activities, and* 25 *school subjects.* In Strong's inventory are included 100 *occupations,* 54 *amusements,* 39 *school subjects,* 52 *activities,* 53 *peculiarities of people,* 40 *order of preference of activities,* 42 *comparison of interest, and* 40 *ratings of present abilities and characteristics.* On each item the subject is required to give an expression of *liking, indifference,* or *dislike.*

[82] L. Fejgin-Garstenteyg, *Certaines Manifestations du Caractère et du Tempérament dans les Epreuves psychotechniques,* V-e Conference International de Psychotechnique, Utrecht, 1928, p. 11.

[83] See Chapter VIII, pages 137–41.

[84] B. V. Moore, "Personnel Selection of Graduate Engineers," *Psych. Mono.,* No. 138, (1921), pp. 85; J. B. Miner, "An Aid to the Analysis of Vocational Interests," *J. Ed. Res.,* 5 (1922), pp. 311–323; M. J. Ream, *Ability to Sell: Its Relation to Certain Aspects of Personality and Experience,* Baltimore, 1924, pp. 64; M. Freyd, "The Personality of the Socially and Mechanically Inclined," *Psych. Mono.,* No. 151 (1924), pp. 101; D. Fryer, *Measurement of Interests,* New York, 1931, pp. 488.

[85] K. M. Cowdery, "Measurement of Professional Attitudes, Differences Between Lawyers, Physicians and Engineers," *J. Pers. Res.,* 5 (1926–27), pp. 131–141.

[86] E. K. Strong, Jr., "An Interest Test for Personnel Managers," *J. Pers. Res.,* 5 (1926–27), pp. 194–203; "Diagnostic Value of the Vocational Interest Test," *Educ. Rev.,* 10 (1929), pp. 59–68.

[87] G. E. Manson, "Occupational Interests and Personality Requirements of Women in Business and the Professions," *Mich. Bus. Studies,* No. 3 (1921), pp. 281–409.

In the case of the Strong interest inventory an examination of successful men in approximately 20 occupations is made the basis for weighting each item so as to make possible a comparison between the likes and dislikes of a subject with those of successful men in these particular occupations.[88]

Manson provides keys for distinguishing the interest of women in 10 occupations, viz: *private secretary, office manager, bookkeeper, stenographer, office clerk, high school teacher, grade school teacher, trained nurse, retail saleswoman, sales proprietor.*

The interest inventory seems the most promising method for gauging interest because of its objectivity, by reason of the uniformity of conditions of application, and because more satisfactory standards are available for this particular type of interest test than for any other which has been used. At the same time, the usefulness of this technique is limited by the fact that in the case of men, at least, scoring keys are available for only a few occupations below the professional level. Strong's inventory can be scored for general office worker, vacuum cleaner salesman, life insurance salesman, and for one or two other occupations of a non-supervisory or technical nature. These levels are also represented in Manson's inventory, but as far as industry is concerned, the scoring keys for lawyer, doctor, high school teacher, and similar occupations are not particularly useful. The value of the interest inventory is further limited by the fact that although it is possible to distinguish between the "mechanically" and "socially inclined," [89] and although one occupational group can be distinguished from several others, *interest in a single occupation can not be distinguished from that in any other with a degree of accuracy valuable for practical purposes.*[90] Moreover, in the case of none of the interest inventories has the exact relationship between score and achievement and adjustment on the job been satisfactorily established.

(7) THE VALIDATION OF THE TESTS

From the viewpoint of ultimate usefulness, one of the most important steps in the research program for the development of tests is the determination of whether the test or battery of tests actually taps qualities of importance in success on the job, and whether it can be used in predicting such success. This involves a comparison between test score and proficiency on the job as represented in the criteria. If this com-

[88] E. K. Strong, "Procedure for Scoring an Interest Test, *Psych. Clin.,* 19 (1930), pp. 63–72.

[89] M. Freyd, *op. cit.;* R. M. Hubbard, "Interests Studied Quantatively," *J. Pers. Res.,* 4 (1926), pp. 365–378.

[90] Thurstone has recently demonstrated that in 18 professions for which keys are available on the Strong interest blank, interest can be fairly well accounted for by postulating only 4 general factors: (1) interest in science, (2) interest in language, (3) interest in people, and (4) interest in business. (L. L. Thurstone, "A Multiple Factor Study of Vocational Interests," *Pers. Jour.,* 10 (1931), pp. 198–205.)

VOCATIONAL INTEREST BLANK

BY Edward K. Strong, Jr.

PROFESSOR OF PSYCHOLOGY, STANFORD UNIVERSITY

It is possible with a fair degree of accuracy to determine by this test whether one would like certain occupations or not. The test is not one of intelligence or school work. It measures the extent to which one's interests agree or disagree with those of successful men in a given profession.

Your responses will, of course, be held strictly confidential.

PARTS IA AND IB. *Occupations.* Indicate after each occupation listed below whether you would like that kind of work or not. Disregard considerations of salary, social standing, future advancement, etc. Consider only whether you would like to do what is involved in the occupation.

Draw a circle around L if you like that kind of work.

Draw a circle around I if you are indifferent to that kind of work.

Draw a circle around D if you dislike that kind of work.

Work rapidly. Your first impressions are desired here. Answer all the items. Many of the seemingly trivial and irrelevant items are very useful in diagnosing your real attitude.

Actor (not movie)	L	I	D
Advertiser	L	I	D
Architect	L	I	D
Army Officer	L	I	D
Artist	L	I	D
Astronomer	L	I	D
Athletic Director	L	I	D
Auctioneer	L	I	D
Author of novel	L	I	D
Author of technical book	L	I	D
Auto Salesman	L	I	D
Lawyer, Criminal	L	I	D
Lawyer, Corporation	L	I	D
Librarian	L	I	D
Life Insurance Salesman	L	I	D
Locomotive Engineer	L	I	D
Machinist	L	I	D
Magazine Writer	L	I	D
Manufacturer	L	I	D
Marine Engineer	L	I	D
Mechanical Engineer	L	I	D
Mining Superintendent	L	I	D

PART II. *Amusements.* Indicate in the same manner as in Part I whether you like the following or not. If in doubt, consider your most frequent attitude. *Work rapidly.* Do not think over various possibilities. Record your first impression.

Golf	L	I	D
Fishing	L	I	D
Hunting	L	I	D
Tennis	L	I	D
Driving an automobile	L	I	D
Taking long walks	L	I	D
Boxing	L	I	D
Checkers	L	I	D
Chess	L	I	D

PART III. *School Subjects.* Indicate as in Part II your interest when in school.

Algebra	L	I	D
Agriculture	L	I	D
Arithmetic	L	I	D
Art	L	I	D
Bible Study	L	I	D
Bookkeeping	L	I	D
Botany	L	I	D
Calculus	L	I	D
Chemistry	L	I	D
Civics	L	I	D
Dramatics	L	I	D
Economics	L	I	D
English Composition	L	I	D

parison reveals satisfactory relationship between test scores and success on the job, the tests can then be described as *valid* for selection purpose. The validation of tests involves the application of refined statistical techniques which will not be discussed in this volume.[91] However, the author must again emphasize the fact that no investigation in this field can be undertaken by one unfamiliar with statistical methods. Such familiarity means not merely a knowledge of statistical methods but a very complete knowledge of their limitations and of the scope of application of final figures obtained through their use. As Myers has pointed out, "nothing is more important than that the experimental psychologist should be well grounded in the theory and practice of statistical measurement. But at the same time nothing is more important than that he should know when and how to use this statistical knowledge and skill, employing them not merely mechanically and mathematically but with due regard to psychological considerations." [92]

Procedures in Validation

The comparison of average scores of groups of workers at varying levels of proficiency represents one simple technique for the evaluation of tests. In applying this procedure the experimental group may be divided into *good, average,* and *poor workers,* on the basis of the criteria, and a comparison made of average scores of these groups. Other classifications of job achievement may be used, such as *Best 20 per cent, Middle 60 per cent,* and *Poorest 20 per cent,* but the fundamental principle remains the same—that superior groups of workers must be differentiated from inferior groups by average test scores. The results of such an analysis may be presented graphically, as in Figure 26, showing the average score on a single item of a trade test of novices (N), apprentices (A), journeymen (J), and experts (E); as in Figure 29, showing the average score on a battery of tests of BEST, AVERAGE, and POOREST substation operators, or in other ways. The application of this method invariably involves the use of statistical techniques for determining the significance of differences between groups.

Percentage comparison represents another valuable technique in test valuation that may be used separately or in combination with other procedures. This method involves the determination of the percentage of individuals scoring above or below certain *critical scores.*[93] The use of this procedure may show, for example, that of individuals scoring below 28 on a certain test, 85 per cent failed to succeed on the job and 15 per cent were successful in terms of the accepted criterion, whereas, among those scoring above 28, 74 per cent succeeded and only 26 per

[91] For a discussion of these statistical techniques see *references* cited in footnote 4, page 202.

[92] C. S. Myers, "Psychological Cautions in the Use of Statistics," *Z. Ang. Psych.,* 36 (1930), p. 86.

[93] See page 254.

cent failed.[94] This method is particularly useful where the investigator is primarily interested in the elimination of the poor workers or in the selection of the best workers, and is not so much interested in the excellence of differentiation at the other extreme of test scores or in the middle range. Percentage comparisons are especially helpful in showing how well predictions can be made at *some particular part* of the total range of test scores.

One measure of the value of selection tests is the degree of resemblance between the order of test scores of a group of workers and the

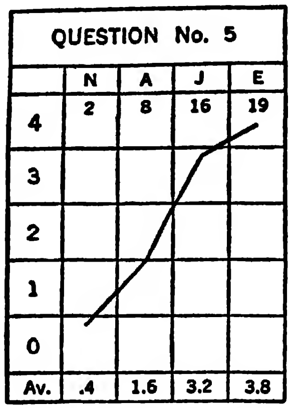


FIGURE 26. *Average Scores of Novices, Apprentices, Journeymen and Experts on Trade Test Item*

(*After Chapman*)

order of their proficiency on the job. The degree of such resemblance is expressed in the coefficient of correlation, and the statistical method of correlation has, for this reason, become one of the most frequently applied techniques in the validation of all kinds of selection tests. Assuming that the sampling of workers is statistically adequate, and that certain other conditions are satisfied, a high correlation represents closer agreement between scores and the working proficiency of individuals in the experimental group than the low correlation. For this reason, tests showing a high correlation with criteria can be used with a higher degree of accuracy in predicting success on the job than those which exhibit a mediocre or low correlation. As indicated in an earlier chapter, if the coefficient of correlation is 1.00 the relation between test score and performance is perfect. This means that the individual who is highest in the test will invariably be highest in working efficiency and that the order of working efficiency coincides exactly with the order of psychological test scores. If the correlation is 0.00 prediction will be

[94] A. W. Kornhauser and F. A. Kingsbury, *op. cit.*, p. 72.

no better than a pure chance guess.[95] Correlation between 0.00 and 1.00 represent predictions better than pure guess. The exact forecasting efficiency value of a coefficient between 0.00 and 1.00 may be expressed in the terms of the percentage better than chance prediction represented in such a coefficient. The forecasting efficiency of coefficient of correlation expressed in these terms is shown on page 88.

It is extremely interesting and important to note that with a coefficient of, for example, .70, forecasting efficiency is no more than 30 per cent better than chance. The fact that in the case of the majority of test batteries employed in industry the coefficient of correlation actually falls below this figure may suggest that there is little reason for going through the laborious and sometimes expensive procedure of preparing and standardizing selection tests. When it is recalled, however, that many of the traditional methods of the Employment Office give results that are no better than chance,[96] there is some encouragement in the even slightly better chances for improved selection given by a coefficient of .50 (13 per cent better than chance). The cost of a single accident in street car operation is often more than the total cost of installation and operation for one year of a selection procedure which serves to eliminate at least a proportion of the "accident-prone" drivers hired when only traditional techniques are used in selection.

In the final analysis, the value of tests lies in the total improvement in the form of reduced costs and better adjustment effected in the organization through their use. This depends in part upon the predictive value of the tests as expressed in a coefficient of correlation and partly upon the skill in administration of tests and in interpretation of results by a competent psychologist. Be that as it may, in so far as the coefficient of correlation *itself* is concerned, the classification suggested by Hull seems to give a fair picture of forecasting efficiency, assuming, of course, that the coefficient is more than 4 times its probable error; that raw data is reliable; etc., etc.

"Below .45 or 50, practically useless for differential prognosis.
From .50 to .60, of some value.
From .60 to .70, of considerable value.
From .70 to .80, of decided value but rarely found.
Above .80, not obtained by present methods." [97]

Other techniques for validation will be illustrated in the discussion of investigations cited in Chapters XIII to XV inclusive.

The Development of Norms

As a preliminary to the use of a test, standards or norms must be established by which to interpret individual scores. This process is

[95] *Ibid.*, pp. 70–71.
[96] See Chapter X.
[97] C. L. Hull, *op. cit.*, p. 276.

sometimes referred to as *calibration*. The simplest procedure is to establish, on the basis of experimental findings, a *critical score*. This is generally a value which separates those who are to be rejected from those who are to be hired. In some instances, an upper and a lower critical score may be established, the first to keep out incompetent workers, and the second to eliminate those who, because ability is superior to the job, tend to leave. The critical score is most frequently obtained by plotting results and by a process of "trial and error," select-

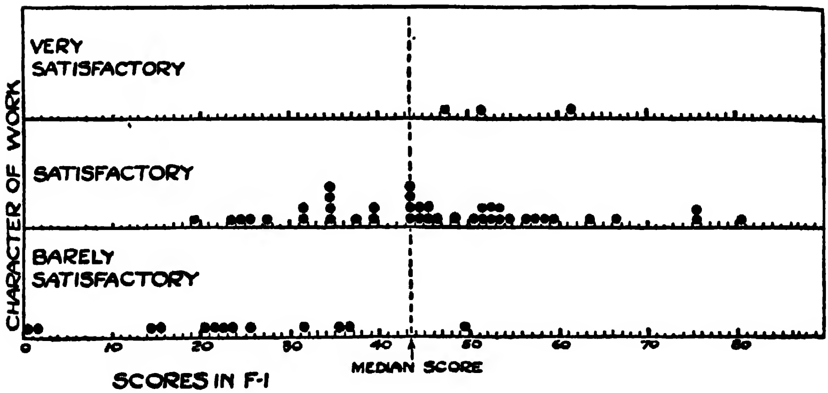


FIGURE 27. *Test Scores of 57 Department Store Cashiers*
(*After Viteles*)

ing that score which most clearly distinguishes between satisfactory and unsatisfactory workers. This procedure is illustrated in Figure 27,[98] showing the distribution of test scores of 57 department store cashiers. In this case the critical score was set at 30. Of barely satisfactory workers 69.2 per cent have scores below this figure. Of satisfactory and very satisfactory cashiers only 11.2 per cent fall below the critical score.

The choice of critical score depends upon factors other than the predictive value of a given score. It may be found, for example, that with a given critical score, the chances are extremely good that none of those hired will fail on the job. However, if 90 per cent of the applicants are rejected on this basis, and the labor supply is meagre, the score will not be workable. In practice the critical score is generally that which permits the acceptance of the largest possible percentage of satisfactory applicants and the rejection of the largest possible percentage of unsatisfactory applicants within the limits determined by the available supply of labor. For this reason, in hiring, the critical score, within certain limits, is frequently set at a higher point when labor is plentiful than when it is scarce.

[98] M. S. Viteles, "Selecting Cashiers and Predicting Length of Service," *J. Pers. Res.*, 2 (1924), pp. 467–473.

In addition to critical scores, a series of standards or norms may be specified. A total range of scores may, for example, be divided into 5 groups [99]—from "very good" to "very poor." *Decile scores,* which specify whether the applicant is in the lowest tenth, or third lowest tenth, etc., in comparison with the experimental group may be used. Upon occasion it may even be desirable to use a *percentile score,* which makes it possible to determine the percentage of those on the job obtaining scores higher or lower than that obtained by the applicant.

Other methods are available—their use depending upon the conditions of the study. Regardless of the method employed in establishing norms, or standards of employment, the one guiding principle must be that they are subject to change as preliminary results are repeatedly followed-up and checked to determine how well the established norms work in practice.

Measuring Reliability

One measure of a satisfactory test, and of every other selection device, is its *reliability*. To be reliable a test or battery of tests must be a consistent measure of the relative ability of the members of a group. On a repetition of the test each individual in a group should maintain a position varying little from his rank in the first application of the test. Reliability can be determined either by means of a second repetition or by statistical techniques involving a correlation of the even and odd numbered halves of a test, by the correlation of alternate forms, etc. Reliability is expressed in terms of the coefficient of correlation. The minimal reliability necessary for use varies considerably with circumstances. According to Freeman "it is a matter of judgment as to how high a reliability coefficient must be in order that the test may be regarded as satisfactory. Certainly, a coefficient as low at 0.50 represents little reliability. Perhaps we may say that 0.70 is the lower permissible limit of such a coefficient. Anything below this means that the test gives very variable results when repeated. We may, however, consider this as fairly satisfactory." [100] According to Garrett, "to be a reliable measure of capacity, a mental or physical test should—generally speaking—have a minimum reliability coefficient of at least .80." [100a] Others insist on a reliability above .85 and still others upon a minimum of .90. Although it is common practice to insist upon reliability coefficients, there has recently developed a somewhat critical attitude with respect to their continued use. However, this particular controversy and other "dangers which arise in the routine mechanical application of statistical methods to psychological problems" [101] cannot be considered here.

[99] A. W. Kornhauser and F. A. Kingsbury, *op. cit.*, pp. 74–75.
[100] F. N. Freeman, *Mental Tests*, Boston, 1926, p. 72.
[100a] H. E. Garrett, *Statistics in Psychology and Education*, New York, 1926, p. 269.
[101] C. S. Myers, *op. cit.*, pp. 82–83.

(8) ADMINISTRATION OF SELECTION TESTS

The results to be obtained from the use of tests depends in part upon conditions of administration, since "the value of tests is determined by the way they are used as well as by the merits of the tests themselves." [102] Suitable examination quarters must be provided. Provisions must be made for scheduling applicants to permit the most economical use of the tests, and procedures established for dovetailing the psychological examination with the other functions of the employment office, so as to make the most effective use of test data in combination with other information obtained on the application blank, during the interview, etc. Instruction manuals, procedures for scoring individual tests and for weighting the tests in a battery must be provided so that absolutely uniform conditions may be maintained in the administration and scoring of the tests. Forms for recording results and files which permit ready analysis of results must be prepared. Arrangements must be made for a frequent follow-up of testing procedures as a means of improving forecasting efficiency and of studying the gain in efficiency and adjustment in comparison with operating costs.

The Qualitative Analysis of Test Performance

Of equal importance in the successful administration of a testing program is the employment of an examiner capable of supplementing test scores with qualitative analysis of performance as an aid in gauging individual fitness for work. The development of self-administering tests and automatic recording devices, the wide dissemination of information concerning tests among laymen, have tended to create the impression that the administration of the test is a highly routine matter that can be placed in the hands of a relatively untrained person. This procedure finds support in the viewpoint expressed by Freyd that "it requires more training to conduct an experiment in vocational tests than to administer the tests. An economy of effort will result if the experimenter assigns the task of administering the tests to another. He should insist on the selection of a tester who is fairly intelligent, polite and tactful, and favorably inclined toward the theory of tests and scientific method in general." [103] Politeness and tact are essential qualities in an examiner, but they cannot completely replace the diagnostic skill which must be applied in the interpretation of objective scores in order to make the most effective use of testing devices. The orientation in Freyd's position is a *statistical* one, which contends that "the test score in the practical situation is always the known variable and from it the probable degree of vocational success may be predicted on the basis of the known relationship of test scores and degrees of vocational success. Evaluation of the tests consists (exclusively) in the compari-

[102] A. W. Kornhauser and F. A. Kingsbury, *op. cit.*, p. 162.
[103] M. Freyd, "Measurement in Vocational Selection," *J. Pers. Res.*, 2 (1923–1924), p. 377.

son of two series of measurements made of the subjects of the experiment, the test scores and the criterion of success." [104]

The technical defects of the statistical approach have been briefly considered in the cautions on the use of statistical techniques included in the discussion of test validation. The experience of the clinical psychologist in examining children and adults for educational purposes, for correctional and vocational guidance has served further to reveal the weaknesses of the purely statistical approach in vocational selection. In such cases it has been found impossible to diagnose and treat on the basis of objective test scores alone.[105] It has been discovered that there is a qualitative aspect of mental analysis which goes hand in hand with quantitative analysis—that the objective data of mental measurement must be supplemented with the observation and analysis of performance. As Maxfield has pointed out, "in the use of standardized mental tests subjective judgments of the experienced examiner in regard to the qualitative aspect of the subject's reactions, whether verbal responses or other types of behavior, are significant." [106]

Likewise in industry it must be recognized that the competency of the applicant for a great many jobs, perhaps even for a majority of them, cannot be wholly predicted from an objective score any more than the ability of a child to profit from one or another kind of educational treatment can be wholly gauged from such a score. There is no reason for suspecting that the capacity of an individual motorman to avoid accidents, or of a printer's apprentice to profit from instruction in this trade can be expressed in an objective score, as easily interpreted by a minor clerk as by a trained psychologist, than for suspecting that the mental status of a child is revealed in the I. Q. which can be obtained by any teacher who owns a copy of Terman's "Condensed Guide" and a set of testing material. The one problem is as complicated as the other; the objective score in one case has in it as many elements of error as in the other; and an adequate diagnosis in both involves interpretation by a trained psychologist based on observation of performance and a consideration of related data.

The character of such an analysis is illustrated in Figure 28, showing the qualitative study of performance on an early model of the Viteles Motorman Selection Test. In the application of the electrical substation operator tests described in Chapter XIII a great deal of attention is paid to the shape of the test profile, as well as to the objective score. It has been discovered, for example, that regardless of the objective total test score, operators whose paper test scores (Series A) are higher than their performance scores (Series B) are generally less satis-

[104] *Ibid.*, p. 272.

[105] M. S. Viteles, "The Clinical Viewpoint in Vocational Psychology," *J. App. Psych.*, 9 (1925), pp. 131–138.

[106] F. N. Maxfield, "The Use and Abuse of Standard Intelligence Tests in Individual Examinations," *Proceedings 48th Annual Session for the Study of the Feeble-minded*, 1924.

factory workers. In addition, an analysis of the regularity and irregularity of the profile has suggested that there exists a definite relationship between the degree of irregularity of the profile and the performance and general stability of the operator.[107]

Recent years have witnessed a growing emphasis upon the qualitative analysis of test performance. The present tendency is evident in the

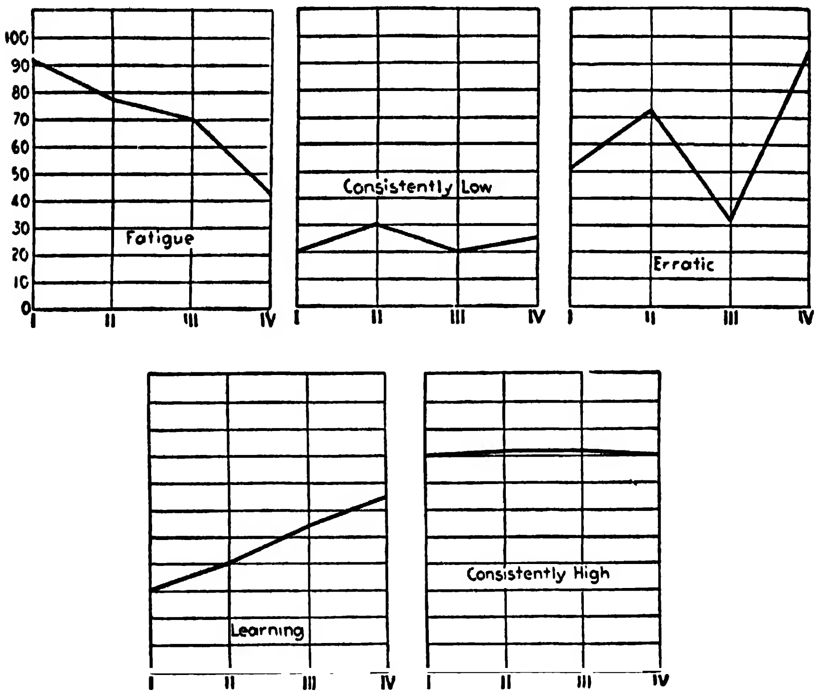


FIGURE 28. *Analysis of Motormen Test Records*
(*After Shellow*)

long and detailed schedules prepared by Baumgarten,[108] for recording observations made in the course of the psychological examinations of workers. The social implications of a purely statistical orientation have been well stated by Young, who condemns the exclusive concern with statistical and quantitative classification as "part and parcel of the general trend toward mechanization and standardization of life, consequent upon the application of science to human endeavor, in industry,

[107] See Figure 10b.

[108] F. Baumgarten, "Feuille pour l'Enregistrement des Observations sur la Conduite du Sujet pendant l'Examen psychotechnique," *VI a Conferencia Internacional de Psicotecnica*, Barcelona, 1930, pp. 225–230; "Merkblatt für Deutung des Verhaltens der Prüflinge während der Arbeitsprobe," *Psychot. Z.*, 5 (1930), pp. 115–119.

in education, in the military. It is an inevitable effect," he writes, "of a materialistic civilization. In this mad rush for mass production, be it in the classroom product or in business enterprise, the trend is ever and anon toward those values which are expressible in quantitative units. We are rapidly losing our older notions of quality, of calm and divergently integrated personalities. If the older laboratory psychology produced a psychologic man which had no individuality, the statistical treatment of him in terms of I. Q. and score, buttressed by averages of correlation quotients, tends to make man a psychological robot with no emotion, no quality, no personality." [109] In contrast with this statistical viewpoint is the newer, *clinical viewpoint,* which emphasizes not the score, but the individual; not the selection of a group of workers, but the placement of the *individual,* with the objective of promoting *his* efficiency and *his* adjustment in the industrial situation.

[109] K. Young, "The History of Mental Testing," *Ped. Sem.*, 31 (1924), p. 48.

XIII. TESTS FOR SKILLED AND SEMI-SKILLED WORKERS

INTRODUCTION

In this and the two chapters which follow will be briefly described the methods of a *few* typical projects involving the use of tests in the selection of workers. These chapters do not pretend to give a complete picture of the present status of testing in industry.[1] There will be no reference to many jobs on which investigations have been carried out. Few of the studies included in these chapters will be described in detail. Their object is to present a sampling of investigations in a few occupational fields in order to give the reader an appreciation of methods and results. However, in order to round out the discussion on research procedures in testing included in Chapters XI and XII, one study, involving the selection of semi-skilled workers, will be described in detail. This investigation, conducted by the author, is concerned with the development and follow-up of a battery of tests used in the placement of electrical substation operators.

SPECIFICATIONS AND TESTS FOR ELECTRICAL SUBSTATION OPERATORS PHILADELPHIA ELECTRIC COMPANY [2]

Economy in the distribution of electric current involves generation and transmission at high voltages which are reduced at electrical substations prior to the delivery of current to the consumer. The substation

is supplied with a number of lines over which current is received from generating stations and a greater number of circuits over which current (at a lower voltage) is transferred directly to individual consumers or to equipment through which a number of consumers are served. A great variety of equipment for transforming and regulating voltages, a great number of recording meters, relaying and other protective devices, rotative equipment, etc., are tied in with these lines and circuits. The operation of this equipment involves the manipulation of numerous switches. The manipulation of these switches, the reading of meters, and the care of the station and its equipment in such a manner as to provide regular and uninterrupted service to the consumer represent the chief duties of the electrical substation operator.[8]

The chief responsibility of the operator is to avoid errors in switching. The consequence of such an error may be very serious. The unexpected failure of lights or power equipment, in a hospital, particularly if an operation is being performed at the time, may be disastrous. There are industrial operations in which even a momentary interruption may cause serious damage to material in the process of manufacture. So, for example, in the manufacture of rayon the failure of the supply of power to machines causes a break in the manufacturing process involving considerable loss to the manufacturing concern. In an ice plant the entire product in operation at the moment—at times a hundred tons—will become practically worthless if the current is shut off for a few minutes. The entire load of a grain elevator may be dumped upon the operating motor if the current is interrupted for even a fraction of a minute. In addition to such inconveniences and losses, and possible damage to very expensive equipment in the substation itself, there may be more serious consequences of an operating error in the form of injury to the operator or actual loss of life. This is especially apt to be the case when the man undertakes to handle, as "dead," equipment which is actually alive. Mechanical and electrical safeguards against such occurrences are provided, but these cannot completely take the place of human control exercised by an operator, physically and mentally competent, and prepared by suitable training to handle the job.

Inaccuracy in operation can in part be avoided through suitable training. In recognition of this, in the Philadelphia Electric Company prospective operators are hired as assistant operators and given technical training in substation operating practices and in electrical theory. Each employee is required to spend a year as an assistant operator before he is promoted to the rank of operator and entrusted with the operation of the substation. However, in spite of similarities of training,

[8] The physical conditions under which he works and the character of the modern switchboard which the substation operator controls in providing regular and uninterrupted service can be seen from the picture of a portion of a typical electrical substation shown on Plate II.

certain operators have been found to be more reliable, that is, less susceptible to errors, than others. This suggested to the Superintendent of Substations of the Philadelphia Electric Company that there may exist a predisposition toward error which could be determined prior to employment—that it might be possible to set up specifications and to devise tests to determine before employment whether an applicant would prove thoroughly reliable as an operator. In accordance with this thought, in March, 1927, the author undertook to analyze the occupation of substation operator and to prepare tests for the selection of competent operators. The investigation was originally oriented as a problem in selection, but there have been valuable by-products in the systematization of training and in the development of follow-up methods, etc. which will not be reported upon in this chapter.

The Analysis of Substation Operation and Qualifications of the Substation Operator

The first step in this investigation took the form of determining the abilities necessary for successful accomplishment in the work of substation operation. Several methods were used in studying the mental requirements of the job. In the first place, an assistant was placed in the substations for a period of approximately three months, performing the work of an assistant substation operator and receiving intensive training in substation operation. Secondly, the author spent considerable time, over a period of four months, in visiting various types of substations and in closely observing and analyzing the work of substation operators. In addition, supervisors and others were asked to prepare "job psychographs" or descriptions of the various requirements of the job in accordance with the procedure which the author has described elsewhere.[4]

The analysis of the duties and mental requirements of substation operators under *normal conditions* showed that the following abilities are necessary for satisfactory operation. It is these abilities which largely determine the individual's *proneness* to error in switching under normal conditions and which must be measured in selecting operators least liable to such errors.

a. *Ability to learn and to recall in proper order* the complex series of switching operations with which the operator must be familiar.
b. *Accuracy in following directions* and in employing knowledge of substation operation in switching and blocking.
c. Ability to *comprehend* readily *instructions* given either verbally or in writing.
d. Persistence in keeping at a problem until it has been solved, or until the operator has *satisfactory* reason for believing that the problem cannot be solved by methods at his disposal.

[4] See Chapter IX, pages 147–53.

e. *Judgment* and *analysis* in solving a new problem, e. g., in locating and remedying trouble.
f. Ability to give co-ordinated attention to a number of different operations or things at the same time; to *spread attention* over the details of a blue print, over the correct switching handle, ammeters, etc.
g. Ability to carry in mind the *location* of equipment in substations and an image of wiring arrangements, etc.

In the case of *emergency conditions* the outstanding qualities making it possible to continue safe and accurate operation seem to be temperamental in character. For accurate operation in emergency conditions the operator must be capable of resisting fear. In substation operation the effect of fear is generally displayed in an immediate loss of accuracy, in increase of the time taken to clear up trouble, and in a general loss of certainty and reliability which may extend over a considerable period of time following the appearance of the disturbing stimulus. Such a change may occur even in the case of operators who have demonstrated their ability to operate satisfactorily under normal conditions. It therefore seemed necessary, in the development of tests for the selection of substation operators, to provide distinct instruments for the measurement of fear resistance and the associated temperamental traits which play a dominant rôle in determining response under emergency conditions.

The Make-up of the Test Series

Subsequent to the analysis of the work of the substation operator, and the development of the criteria described below, tests were prepared to measure the mental abilities and temperamental traits necessary for safe and accurate substation operation under all conditions. The tests finally selected for use as valid instruments in the selection of competent operators are divided into three series.

Series A includes five tests of the paper and pencil type:

1. *Pursuit Test.*
2. *Blocks B.*
3. *Blocks A.*
4. *Location Test.*
5. *Series Completion Test.*

Tests 1, 2, and 4 in Series A are adaptations of tests of the same name embodied in the McQuarrie Tests of Mechanical Aptitude. Tests 3 and 5 are adapted from Army Beta.

Series B consists of the following four performance tests:

1. *Healy Puzzle Box.*[5]
2. *Direction Test,* a test designed by the writer for the purpose of measuring individual differences in the ability to comprehend readily, and to follow accurately, instructions given either verbally or in writing. It involves a series of 24 orders for the manipulation of the switch panels and boxes which make up the test. (Plate II.)
3. *Learning Test,* an adaptation, both in design and administrative procedure of the Langfeld series reaction apparatus, used hitherto in laboratory experiments, but employed for the first time, in so far as the writer is aware, in an industrial investigation. It is used as a test of the ability to learn and recall in proper order the complex series of switching operations with which the substation operator must be familiar.
4. *Persistence Test.*[6]

The tests in Series A and Series B are used to measure predisposition to work satisfactorily under normal operating conditions. Tables have been prepared for transmuting the scores on the individual tests so that each is given equal weight in a *Total Test Score* embodying performance on all of the tests in Series A and B. Reference will be made to this *Total Test Score* in describing the validation of these tests. The reliability of the series as determined from a re-examination of 18 assistant operators, approximately 10 months after the first examination, is + 0.79.

Series C includes one test, known as the *Switching Control Test* (Plate II), designed by the author in co-operation with various members of the organization for the purpose of measuring the capacity to maintain safe and accurate operation under emergency conditions.[7] The validation of Series C (Switching Control Test) has not yet been completed and no report of such validation will be included in this chapter. The test is here described as a matter of interest in connection with the development of the program for testing substation operators. However, it may be in place to state that the preliminary evidence so far obtained favors the validity of the test as a measure of proneness to unreliability in an emergency.

Validation of the Tests

(a) *Selection of Criteria*

As a preliminary to their adoption as employment instruments, the validity of the tests as measures of predisposition to error was examined

[5] A. F. Bronner, W. Healy, G. M. Lowe, M. E. Shimberg, *A Manual of Mental and Physical Tests,* Boston, 1927, p. 103.

[6] J. J. B. Morgan and H. L. Hull, "The Measurement of Persistence," *J. App. Psy.*, 10 (1926), pp. 180–187.

[7] The average time taken for the examination on Series A and Series B is approximately two and a half hours. Another half hour is required for Series C. (Switching Control Test.)

by a comparison of test scores with the operating records of an *experimental group* including 84 operators, each one of whom had been working as an operator for not less than 1 year and not more than 10 years.

As the first step in this comparison of test scores and operating efficiency these operators were divided into three groups designated as *Best, Average,* and *Poorest,* respectively. A group of 13 men, including 7 load dispatchers and 6 members of the supervisory force of the Substation Section, all of whom were in close contact with the operators, were asked to co-operate in classifying them. Each of these men was given a sheet listing the names of the operators included in the experimental group, and asked to place a B before the name of each operator whom he considered to be one of the best and a P before the name of each operator whom he considered to be one of the poorest operators in the employ of the Substation Section. Each substation operator was then allowed a credit of + 1 for each time that he was selected for the Best group, and a credit of — 1 each time that he was selected for the Poorest group.

When scored in this way, certain operators were selected for the Best group as many as 12 times, receiving a total credit of + 12 and other operators were selected for the Poorest group as many as 12 times, receiving a total credit of — 12. When rating scores were computed for all operators, by finding the algebraic sum of + and — credits, 17 operators were found to have received a score of + 5 or more, and 13 operators a score of — 5 or less. The former were selected as members of a group of representative *Best* operators and the latter as a group of representative *Poorest* operators. The remaining 54 operators, obtaining scores ranging in value from + 4 to — 4 were designated as a group of *Average* operators.[8] It is significant to note that all three groups are practically identical with respect to the distributiton of age and length of service and with respect to the average age and length of service of the members of the group. This indicates that actual efficiency and not length of service was weighted by those responsible for the classification, in the selection of *Best, Average,* and *Poorest* operators.

As a preliminary step in the validation of the tests in Series A and Series B, a comparison was made of the test scores of the *Best, Average,* and *Poorest* operators. The results of this comparison are embodied in the tables and figures presented below. However, it was felt that such subjective ratings might be altogether unreliable in differentiating among the operators with reference to their actual efficiency in substation operation. It was therefore decided to make use, in addition, of available records on switching errors in setting up a more definite criterion of

[8] When the investigation was started, in March, 1927, there were actually 98 men in the experimental group divided into 20 Best, 60 Average, and 18 Poorest operators. The experimental group included all with the exception of 10 operators employed in the Substation Section. On September 30, 1928, the date of the last comparison included in this report, the group had been reduced by promotions, transfers, separations, etc., to the 84 operators with whom this section of the report is concerned.

operating efficiency. It was found that an accurate record of operating errors had been maintained in the company files beginning with January 1, 1926.[9]

In June, 1927, a preliminary comparison of operating errors of men in the *Best, Average,* and *Poorest* group was prepared. The results of this analysis are shown in Table 25 which reveals a definite tendency on the part of the *Best* operators to make fewer errors than *Average* operators and for *Poorest* operators to be responsible for a greater proportion of errors than the *Average* and *Best* operators. It was felt that these figures tended to confirm the ratings made by supervisors and load dispatchers as valid estimates of the operating ability of men employed in the substations. The *validity* and *reliability* of the ratings have been further examined by periodic comparisons of increases in the operating errors of *Best, Average,* and *Poorest* operators, subsequent to the date of the first comparison. There has been found a consistent tendency for a marked increase in the number responsible for operating errors in the case of men classified as *Poorest* and *Average,* and for only a negligible increase in the case of those classified as *Best.* The increase in number of *Average* operators responsible for errors is proportionately less than that of *Poorest* operators. In addition, the difference among the three groups with respect to percentage responsible for errors remains quite constant. These facts are readily observable in Table 25 embodying a comparison of operating errors of men in this group at the end of June 30, 1927, and September 30, 1928, including a record of errors over periods of 1 year, 6 months and 2 years, 9 months, respectively.

TABLE 25

Operating errors of substation operators

OPERATORS *	NUMBER OF MEN IN GROUP		PER CENT INVOLVED IN ERROR		NUMBER OF ERRORS		PER CENT OF TOTAL ERRORS		AVERAGE ERROR PER MAN IN GROUP	
	June, 1927	September, 1928	June, 1927	September, 1928	June, 1927	September, 1928	June, 1927	September, 1928	June, 1927	September, 1928
BEST	19	17	10.6	23.5	2	4	6.5	6.3	0.11	0.24
AVERAGE	58	54	27.5	51.9	18	37	58.0	57.8	0.31	0.69
POOREST	18	13	38.7	76.9	11	23	35.5	35.9	0.61	1.77

* Best rated scores of + 5 and above; Average, between − 4 and + 4; Poorest, − 5 and below.

Table 25 shows not only the greater increase in errors on the part of the two groups referred to above, but also shows that on September 30, 1928, *Poorest* operators were actually responsible for *8* times as many

[9] Reports of operating errors are prepared monthly by the Load Dispatcher's office and are filed in the office of the Substation Section. Errors include inaccurate operations actually resulting in the loss of load or potentially capable of bringing about such a loss. Assignment of responsibility to individual operators is made by the Superintendent of

errors per man as *Best* operators and *3* times as many errors per man as *Average* operators. *Average* operators, on the other hand, are shown to be responsible for *3* times as many errors per man as are operators in the *Best* group.

In view of this demonstration of the validity of ratings made by supervisors and load dispatchers in indicating the efficiency of substation operators, it was decided to use these ratings as well as actual records of operating errors in determining the validity of the tests as measures of competency in substation operation. It is to be noted, however, that these ratings are used as a distinct criterion and that, in addition, a detailed comparison between test scores and the purely objective criterion of operating errors has been prepared. Furthermore it is felt that this comparison of operating errors in two successive periods of time furnishes evidence to the effect that the objective criterion—the number of operating errors—is itself a reliable one.

(b) *Results of Try-Out of Tests on Experimental Group*

In Figure 29 are shown the average *Total Test Scores* of *Best, Average,* and *Poorest* operators. The difference in scores among the 3 groups are statistically significant.[10]

A comparison was also made of the average test scores of operators in the experimental group classified with respect to number of errors. The

Substations. All operating errors are discussed at the periodic meetings of the division heads of the Operating Department. At this time, exception to the Load Dispatcher's designation of a particular situation as an error may be taken. In certain, although infrequent, instances such an exception may be allowed and the error removed from the record.

[10] An index known as $\frac{\text{Diff}}{\text{S.D.Diff}}$ tells just how significant a difference is. For example, if $\frac{\text{Diff}}{\text{S.D.Diff}}$ equals 2, the chances are 43 in 44 that the observed difference is real and in the direction indicated. When $\frac{\text{Diff}}{\text{S.D.Diff}}$ equals 3, the chances are 740 in 741. If $\frac{\text{Diff}}{\text{S.D.Diff}}$ is 5, the chances are approximately 3,500,000 to 1 that the difference is real and in the direction indicated. (See W. V. Bingham and M. Freyd, *Procedures in Employment Psychology*, p. 171 ff.) The significance of this measure may be further indicated in the fact that with a $\frac{\text{Diff}}{\text{S.D.Diff}}$ of 2, the chances of the obtained difference being a true difference greater than zero are 98.01. With a $\frac{\text{Diff}}{\text{S.D.Diff}}$ of 3, the chances of the observed difference being a true difference greater than zero are 99.9. (See H. E. Garrett, *Statistics in Psychology and Education*, p. 128 ff.)

"Whenever two or more groups are compared the $\frac{\text{Diff}}{\text{S.D.Diff}}$ must be computed to determine the significance of the findings. The $\frac{\text{Diff}}{\text{S.D.Diff}}$ must be at least 2 to be significant. It should probably be close to 3 to afford a safe basis for selecting employees." (Quoted from D. A. Laird, *Psychology of Selecting Men*.)

The findings concerning the significance of the difference in average Total Test Score

average *Total Test Score* of 42 operators with 0 errors is 70.6; of 42 operators with 1 or more errors 67.9; of 13 operators with 2 or more errors 59.5; of 5 operators with 3 errors 52.2.

An analysis of test scores showed 75.0 to be the "critical score" for

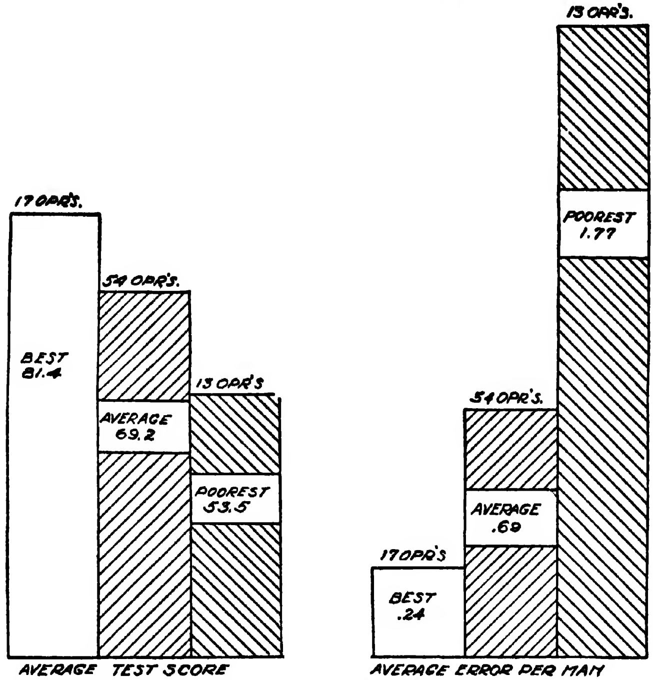


FIGURE 29. *Average Total Test Scores and Average Errors Per Man of 84 Substation Operators*

(*After Viteles*)

selection with this battery. In Figure 30 is presented a comparison of the error record of operators making *Total Test Scores* of 75.0 and above with those making scores below 75.0. The average number of operating errors of the latter is about 2½ times that of the former. It is significant

among BEST, AVERAGE, and POOREST operators are presented in the Table below.

TABLE

The Reliability of Differences in Average Total Test Scores of 84 Substation Operators

GROUPS COMPARED	DIFFERENCES IN AV. TOTAL TEST SCORES	DIFF S.D. DIFF
BEST & AVERAGE	12.2	3.2
BEST & POOREST	27.9	5.2
AVERAGE & POOREST	15.7	3.4

to note that only 7.7 per cent of the *Poorest* operators would have been hired had they been tested prior to employment, whereas 70.6 per cent of the *Best* operators would have been employed. This is of particular significance when it is recalled that the men in the poorest group average 8 times as many errors as those in the best group and that this small group of 13 *Poorest* operators had to the date of this study been responsible for 23 or 35.9 per cent of the errors made by all operators hired

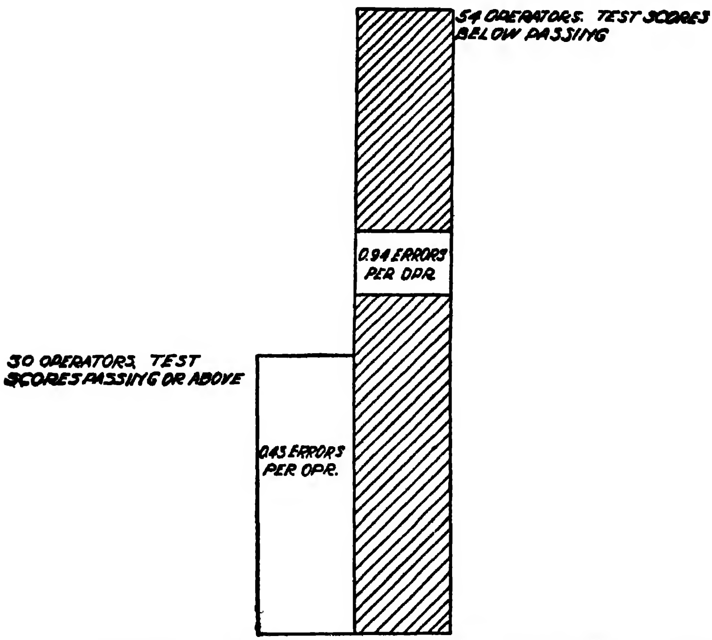


FIGURE 30. *Comparison of Average Operating Errors Per Man of 30 Substation Operators with Passing Scores and of 54 Substation Operators with Scores Below Passing*

(*After Viteles*)

during the last ten years and still in service. On the other hand, the 17 *Best* operators had been responsible for only 6.3 per cent of the total number of errors.

A Study of Substation Assistant Operators

In addition to studying the relationship between test scores and the operating efficiency of this experimental group, a comparison was also made between test scores and efficiency of senior operators. This confirmed the findings of the first study. Moreover, during 1929, a study was made of the status of 35 assistant operators in service for a minimum of 6 months, hired regardless of test score, who had been examined in *Series A* and *B* either before or shortly after employment. These assist-

ant operators were classified as the *Best* (10), *Average* (16), and *Poorest* (9), at a meeting of the Superintendent of Substations, Assistant Superintendent of Substations, and 5 District Supervisors, who carefully reviewed very detailed records on progress in the station and in training which were available. The average Total Test Score of *Best* assistant operators was found to be 87.7; of *Average,* 80.00; and of *Poorest* assistant operators, 68.7.

The Administration of Tests to Applicants for Employment

The tests described in this report have been employed for approximately 3½ years in the selection of substation assistant operators and in connection with the transfer and promotions of operators. A brief description of the routine procedure used in hiring assistants may be of service in showing the place of the tests as administrative units in the selection of competent employees.

Notice of vacancies is sent by the Employing Officer of the Substation Section to the Employment Office. Applicants are interviewed and those found suitable in the preliminary interview, who, in addition, receive a passing score on weighted application blank items, are given a medical examination.[11] Those who pass the medical examination are given the psychological tests by a trained examiner and the results reviewed by the Director of Personnel Research.

Results are recorded on a form, known as the Test Profile (Figure 10b) which shows not only the *Total Test Score* for Series A and B, but the applicant's score on each test in comparison with the performance of *Best, Average,* and *Poorest* operators. This profile has the advantage of showing graphically the position of the applicant on the tests in comparison with those of employees with known proficiency. The profile also reveals whether the applicant's performance tends to be fairly stable on a given level, or whether there is a marked irregularity in performance, as shown by exceptionally high or low scores on single tests. In addition to this objective statement of test results, a complete statement of observations of the reaction of the applicant during the examination is prepared. This is placed on the reverse side of Form PX—501 (Figure 10b), which also contains a detailed statement of the objective score and a description of the quality of performance on Series C (*Switching Control Test*).

No applicant with a *Total Test Score* (Series A and B) of less than 75.00, or with a final rating below *Fair* on the Switching Control Test is hired. On this basis approximately 70 per cent of those examined are refused employment.[12] Final selection is made by the Employing Officer

[11] In deciding upon the suitability of the applicant, the Employment Office makes use of an Application Score, weighting such factors as age, marital status, education, etc., which was prepared by the writer in the course of this analysis of substation operation and the qualifications of the substation operator.

[12] Such applicants are given first consideration for other available jobs.

of the Substation Section, on the basis of all the data made available to him by the Employment Office.

The Tests in Practice

The objective results obtained through the use of these tests are evident in Figure 31, showing charged substation operating errors for the years 1926–31, inclusive. The tests were put into operation in the selection of assistant operators on April 1, 1928. In addition, during that year substation operators who had not been included in the experimental group were examined and the practice established of reassigning operators in service as well as placing new employees on the basis of test scores. So, for example, operators for newer and bigger stations, notably Plymouth Meeting and Westmoreland, were chosen largely on the basis of test score. Notwithstanding the difficulties involved in operating these new, complex stations, particularly during the early stages while a great deal of new and highly complicated equipment was going in, the personnel selected in this way has exhibited a high degree of operating efficiency. On the same basis, operators with low test scores and unsatisfactory working records have been reassigned to the smaller stations.

The net result has been the marked decrease in operating errors shown in Figure 31. During 1931 the number of charged operating errors was one-third of the average for 1926–1928 inclusive.[13] Prior to 1929 there was no month without an error. During 1929 there was 1 month during which there were no errors; during 1930 there were 2 such months; during 1931 there were 2 months without an error and, in addition, a stretch of 3 months without a single error. As a matter of fact, between September, 1931, and April, 1932, there was only 1 error, and this represents the total number for 1932 at the time of writing (June).[14] This improvement follows largely from the use of test scores in the reassignment of experienced operators tested subsequent to employment, supplemented by improvement in the quality of recently hired personnel.[15]

In addition to the decrease in operating errors noted above, the supervisory staff of the Operating Division is convinced that more satisfactory operators are being hired since these tests were installed than was the case previously. Men who have been hired as assistant

[13] If uncharged errors are also considered, the reduction is to one-fourth. Since January 1, 1929, all errors have been charged.

[14] A periodic review has shown that operators with low test scores are continuing to add errors to their records at a rate considerably above that of operators with higher test scores.

[15] The improvement in operating records during the latter part of 1931 and during the early part of 1932 may be partly influenced by the benefits accruing from a supplementary training course, prepared under the direction of the author, which has been given to date to approximately half of the experienced operators. This course was put into operation in 1930. Half of the operating group has completed the course and the other half is at present under training.

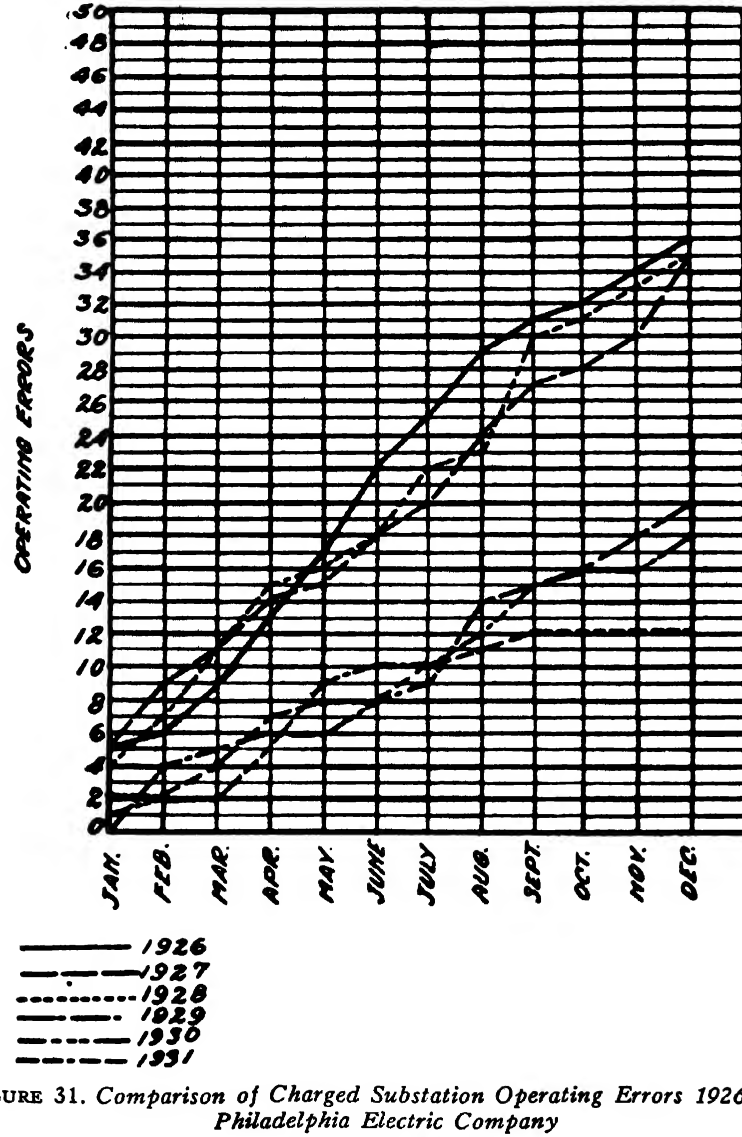


FIGURE 31. *Comparison of Charged Substation Operating Errors 1926–1931 Philadelphia Electric Company*

(*After Viteles*)

operators on the basis of test scores are being promoted to operating positions and seem to adjust themselves to the operator's job more rapidly and more satisfactorily than those hired before the tests were put into operation. The progress of these men who have gradually assumed the full responsibilities of operators is at present being submitted to statistical analysis.

TESTING IN THE MANUFACTURING INDUSTRY

In both the United States and Europe the attention of many investigators has been centered on the development of tests for factory workers. This is not surprising when it is considered that in nations, like the United States, which have passed from an agricultural to an industrial stage, larger and larger portions of the population are being employed in manufacturing pursuits. "Alongside the machinery on which the modern world has grown so dependent are millions of men and women who keep the machinery going. In the United States the largest single occupational class is that engaged in the manufacturing and mechanical industries. The members of this group make up nearly one-third of the working population, and if we add to their number the workers in other occupations that require a certain amount of mechanical skill—some of the branches of agriculture, mining, and transportation—we can estimate that at least 40 per cent of the gainfully employed population is dependent in some measure for its economic success on the possession of mechanical ability." [16]

Link's Studies of Factory Workers

Among the earliest American investigations in the selection of factory employees is Link's work with inspectors, gaugers, assemblers, machine operators, tool makers, and machinists in an arms and munitions plant. In a preliminary experiment with 52 shell inspectors, the correlation between each of 3 tests and the average number of pounds of shells inspected per hour for a 4 week period gave the following figures: [17]

Card Sorting	+0.55
Cancellation	+0.63
Number Group Checking	+0.72

The predictive value of each test was further studied by comparing scores (in seconds) of day workers and piece workers. The latter are naturally the more proficient. Figure 32, showing the distribution of scores for these two groups on the *Number Group Checking Test,* gives a clear-cut indication of the value of this test in discriminating between degrees of proficiency on the job. In addition, the intersection of the

two curves gives the time—or "critical score"—that can be most satisfactorily used as a basis for rejection and employment. The standard set by this critical score is such as to permit the employment of the largest number of applicants likely to succeed, and the rejection of the largest number likely to fail on the job.

The same tests gave unsatisfactory correlations with the production of gaugers, but proved, on the whole, to be suitable for the selection of cartridge and bullet inspectors. A later study showed that of appli-

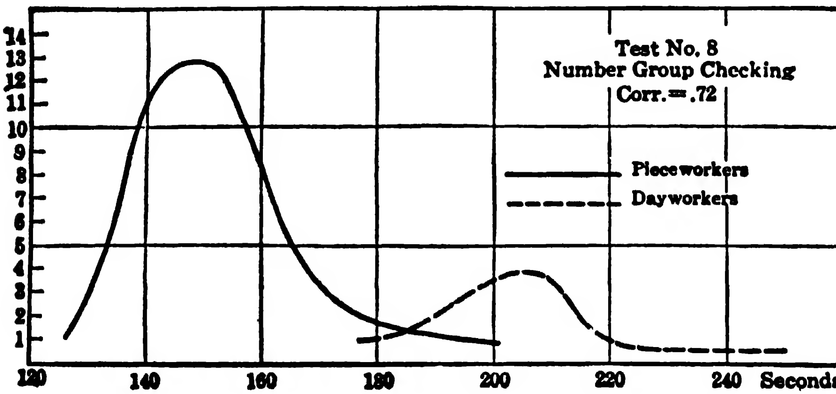


FIGURE 32. *Scores on Number Group Checking Test*
(*After Link*)

cants who had been examined and assigned to inspection, 94 had either stopped work or had been transferred to other jobs. Twenty-seven of these girls had been hired in spite of the fact that test scores were below the standard, because of the labor needs of the plant. An analysis of reasons for discharge or transfer given by the foreman at time of employee's separation is shown in Table 26.[18] A definite relationship between test performance and success on the job is evident in this comparison.

In a still later study it was possible to compare actual test scores on the *Cancellation* and *Number Group Checking* tests with output records,

TABLE 26

	SATISFACTORY	UNSATISFACTORY	NO OPINION	TOTAL
Above the standard	34	1	32	67
Below the standard	1	17	9	27

[18] *Ibid.*, p. 49.

for a period extending from 1 to 4 months, of 43 inspectors who had almost succeeded in becoming piece workers, and who had been at work for 2 months or more. Correlation for the *Cancellation Test* was found to be 0.44; for *Number Checking*, 0.47; and for both, 0.58. Moreover, of all the girls who had been hired as inspectors, those who survived as successful inspectors were the girls who had been above the standard set in the tests. To be specific, 37 out of 43 were producing from 50 to 70 pounds an hour, and of this number all but 2 had been chosen on the basis of the tests. Six were producing less than 50 pounds an hour, and were therefore failures judged by the standard of the shop, and every one of these 6 was decidedly below the standard set by the tests and would not have been hired if the results of the examination had been observed. In other words, out of a group of 39 successful inspectors, all engaged on the very same kind of work for a period of time, 94 per cent were above the standard set by the psychological examination.[19]

Link's investigations included a study in a shop giving a short course of intensive training to prospective machinists and tool makers. In the case of these the following correlations were obtained between foreman's ratings and a battery consisting of the *Stenquist Mechanical Ability Tests,* a *Form Board Test* (similar to that shown on Plate III), and a *Cube Test.*[20]

TABLE 27

Correlations

1st Group (12)	.90
2nd Group (11)	.65
3rd Group (12)	.50

The results, as Link points out, are merely suggestive because of the small number of cases and the subjective character of the criterion, but they are cited as an example of an early American experiment in this field.

The tests devised by Link have been employed either as originally constructed or in a modified form in many other investigations. The experiments conducted by this investigator, and procedures devised by him, in adapting testing techniques to the industrial situation, represent pioneering work in the application of psychology in vocational selection.

Experiments at the Scovill Manufacturing Company

Among more recent American investigations in the selection of skilled and semi-skilled workers is a study by Pond,[21] extending over a period

[19] *Ibid.*, pp. 50–51.
[20] *Ibid.*, pp. 123–129.
[21] M. Pond, "Selective Placement of Metal Workers," *Jour. Pers. Res.*, 5 (1927), pp. 345–368; 405–417; 452–466.

of approximately 10 years, involving an evaluation of 8 tests and of personal history items in the selection of workers for 65 occupational groups in a brass factory (*Scovill Manufacturing Company*). The procedure is such as to give preferred ranges on individual tests and items, and on combinations of tests, which permit every applicant to qualify for one or more positions in the plant. This study is of unusual scope from the points of view of objective, number of workers examined, the periods covered, etc., and involves a painstaking analysis of the reliability and validity of individual tests and criteria. It is characterized throughout by a highly conservative and judicious attitude in the interpretation of data and the formulation of conclusions with respect to the usefulness of the tests.

One feature of the study is the development of a test battery (including four tests of the Army Beta series, errors on one of them and a special circle marking test) for use in selecting tool making apprentices. The battery, on which a preferred range of scores was established in a preliminary experiment with 106 boys,[22] requires only one half hour for administration. The validity of the tests was established by a comparison of test scores with yearly ratings by foremen, based upon instructor's reports, records of performance, etc.

A recent report by Pond [23] reviews the firm's experience with the testing program for this occupation from January 1, 1926 to September 1, 1930. Some of the findings of the analysis are presented in Table 28. The Roman numerals on the left of each table represent the groups of apprentices studied. Group I to III, inclusive, were not selected by test; groups IV to VII were so selected. Group I comprises 57 boys hired prior to any testing, but for whom it was possible to secure ratings at the beginning of the test investigation. The hiring period for group I was nearly four years.

All succeeding groups represent hirings of one year only. Groups II–a and II–b and III cover 106 boys studied to obtain the proper minimum score for the occupation; 37 per cent of them score below the minimum. Groups IV and VII are the boys who were selected from September 1, 1926 to September 1, 1930, from among applicants who scored in the preferred range. Only 8 per cent of them were below the passing mark, and these were close to the critical score. Out of an ample supply of preferred applicants, the final selection of these apprentices was made upon the basis of test scores and all the factors which go to make up an interviewer's judgment.

Column 1 shows the total number of apprentices hired in each group; columns 2 and 3, the number described satisfactory or unsatisfactory in the first foreman's rating; column 4, the percentage satisfactory; column 5, the number of satisfactory apprentices still in the course at time of the rating. Differences between column 5 and column 2 repre-

[22] *Ibid.*, pp. 452–466.
[23] M. Pond, "What is New in Employment Testing," *Pers. J.*, 11 (1932), pp. 13–16.

sent satisfactory apprentices who terminated voluntarily (or were transferred) before the date of rating.[24]

Column 5 is followed by total number of new apprentices still in course at the time of first rating, column 6; and percentage of these who are satisfactory, column 7.

Of apprentices not selected by test, 61 per cent were rated as satis-

TABLE 28

Toolmaking apprentices, quality

		1	2	3	4	5	6	7
	GROUP	NO. H.	NO. S.	NO. U.	PER CENT S.	NO. S. REM.	NO. S. U. REM.	PER CENT OF REM. SAT.
Not selected by test	I	57	36	21	63	32	37	86
	II-a	15	7	8	47	7	11	64
	II-b	35	21	14	60	17	19	89
	III	56	35	22	63	25	32	78
	Total	163	99	64	61	81	99	82
Selected by test	IV	40	36	4	90	24	25	96
	V	44	33	11	75	24	24	100
	VI	35	32	3	91	23	24	96
	VII	36	28	8	78	28	29	97
	Total	155	129	26	83	99	102	97
Difference					+ 22			+ 15
D/e					4.4			3.4

(After Pond)

factory, in comparison to the 83 per cent in the case of those hired by test. The difference is statistically significant. The figures in column 5, as compared with those in column 1, show a stabilization of apprentices in Groups IV to VII. An analysis of these figures shows that fewer and fewer apprentices have to be hired yearly to maintain an even flow of apprentices into the later years of the training course.

Of apprentices still in service at the time of the first rating the proportion of those tested prior to employment receiving a satisfactory rating is 15 per cent higher than among those not tested prior to employment. (Column 7.) "Groups I–III, 61 per cent satisfactory as hired, improved by a process of sifting over a period of one year, average 82 per cent

[24] In normal times apprentices are hired at the rate of two per month, with additional hirings whenever there is an extra opening. The yearly rating is therefore a cross-section, some of the apprentices having been in the course only two months, others longer.

satisfactory at the date of the first rating. Groups IV–VII, 83 per cent satisfactory to begin with, average 97 per cent satisfactory later. A test requiring half an hour per person (less than one half-week total testing time for a year's hiring of boys) is substituted for the weeding otherwise accomplished in a whole year, and produces the same result." [25]

A further analysis of other findings cited by the investigator leads to the conclusion that voluntary turnover of satisfactory apprentices is not affected by the use of a minimum test score in selection. However, the selection procedure has reduced turnover due to failure, and to some extent, length of time required to determine failure.

The Wiggly Block

Among other recent American investigations considerable attention has been aroused by O'Connor's use of a *Wiggly Block*—a rectangular block cut vertically into 9 parts with irregular wavy edges—in the selection of machinists, for the General Electric Company. The investigator reports that 74 per cent of the "all-round" machinists with 2 or more good years standing, who tried the *Wiggly Block,* make A or B grades; of good mechanics, only 5 per cent make D; of 327 mechanical and engineering apprentice boys tested, 44 per cent make A grades and only 5 per cent D. If the test, instead of "judgment" had been used in hiring, these boys would not have been selected. Less than a third of those with D scores are continuing on the job. Half have been dropped, more have left, and several are poor mechanically. "Among the 18 who made C in assembling the block, whom judgment hired, but the test would have rejected, a few have since proved good workers, but only a few." [26]

O'Connor has devised other tests for skilled and semi-skilled workers, e. g., *finger dexterity, peg board,* etc., for use in other jobs. The evaluation of these are characterized by the failure to define criteria, an extremely loose use of terminology, and the absence of substantiating data which are evident in the results and conclusions cited above. For this reason no further reference to this work seems necessary.

THE SELECTION OF METAL TRADE APPRENTICES IN GERMANY

Among European countries, Germany stands in the lead in the development of projects for the selection of skilled and semi-skilled workers. In this country attention has been particularly centered upon the development of tests for the selection and guidance of apprentices in the metal trades. Manufacturers, schools, and labor unions have combined to require the use of such tests as preliminary to an apprenticeship in this industry.[27] A number of separate batteries of tests to be used for

[25] *Ibid.*, p. 15.
[26] J. O'Connor, *Born That Way*, New York, 1928, pp. 123–125.
[27] M. S. Viteles, "Psychology in Business in England, France and Germany," *Ann Am. Acad. Pol. Soc. Sci.*, 110 (1923), pp. 207–220.

this purpose have been devised by independent investigators. Perhaps the leading figures in this field are Moede,[28] Lipmann,[29] Heilandt,[30] Hildebrandt,[31] Rupp,[32] and Poppelreuter,[33] each of whom has developed and standardized a separate battery to be used for this purpose. The testing techniques of the first three investigators resemble each other closely. The tests used by Rupp differ somewhat from these while Hildebrandt appears to have made use of material drawn in part from the work of these investigators and in part from other sources. In general, their methods agree in their use of a group of tests measuring underlying abilities presumably involved in mechanical operations of the type performed by apprentices under training as machinists, tool makers, tinsmiths, for foundry work, and in other related occupations in the metal industry. In many instances the tests are analytic in character, although among them are found a number of the analogous type. Poppelreuter, as an exponent of the work-sample method and of the study of total personality, employs largely work-samples in arriving at a clinical picture of the individual as an aid in selection.

Selection of Apprentices in the Siemens-Schuckert Works—Berlin

The procedure employed by Rupp [34] and a few of his findings may be employed to illustrate the general approach in German studies in the selection of apprentices. Rupp has used a series of 18 tests, measuring primarily *visual discrimination, spatial perception, technical comprehension,* and *manual ability,* for forecasting success in this type of work. The tests, which are given as group examinations, require approximately 5½ hours, supplemented by individual interviews.

Figure 33 A shows a test employed in the Rupp battery as one measure of *spatial perception.* The subject is presented with a sheet showing the designs illustrated in this figure. He is instructed to assume that each figure is made of cardboard, and asked to prepare a drawing

[28] W. Moede, "Die psychotechnische Eignungsprüfung des industriellen Lehrlings," *Prak. Psy.,* 1 (1919), pp. 6–18; 65–81; "Psychotechnische Eignungsprüfungen in der Industrie," *Prak. Psy.,* 1 (1920), pp. 339–350; 365–37, "Germany Finds a Psychological Center Useful," *Ind. Psych.,* 1 (1926), pp. 551–552; *Lehrbuch der Psychotechnik,* Berlin, 1930, p. 140.

[29] O. Lipmann and O. Stoltzenberg, "Methoden zur Auslese hochwertiger Facharbeiter der Metallindustrie," *Schrift. Psych. Beruf.,* 11 (1926), p. 102; "Bewährungsuntersuchung von Eignungsprüfungen in der A.E.G.," *Psychot. Z.,* 3 (1927), pp. 152–155.

[30] A. Heilandt, "Psychotechnische Eignungsprüfungen bei der Einstellung gewerblicher Lehrlinge in der Werkschule der A.E.G. Fabriken Brunnenstrasse," *Betrieb,* 3 (1920), pp. 16–21; "Über der Bewahrung der psychotechnishen Eignungsprüfungen gewerblicher Lehrlinge," *Betrieb,* 4 (1921), pp. 118–121.

[31] H. Hildebrandt, "Versuche mit Psychotechnischen Eignungsprüfungen für Ingenieurlehrlinge," *Ind. Psychot.,* 2 (1925), pp. 42–49; "Beiträge zur Methodik und Praxis der psychotechnischen Eignungsprüfungen auf Grund von Untersuchungen bei der Firma A. Borsig," *Psychot. Z.,* 1 (1925), pp. 49–57; 1 (1926), pp. 187–194.

[32] H. Rupp, "Untersuchung zur Lehrlingsprüfung bei Siemens-Schuckert, Berlin," *Psychot. Z.,* 1 (1925), pp. 54–75.

[33] W. Poppelreuter, "Psychologische Berufsprüfungen insbesondere der industriellen Lehrlinge," *Z. Christ. Erz. Wi.,* 3 (1920), pp. 109–115; "Die Arbeitskurve in der Diagnostik von Arbeitstypen," *Psychot. Z.,* 3 (1928), pp. 35–51.

[34] H. Rupp, *op. cit.*

showing the appearance of this figure if it were opened up and the surface laid out flat on a table. Figure 33 B shows the scoring stencil employed in grading the subject's drawings. The instructions and demonstration on this test require approximately 10 minutes, and 15

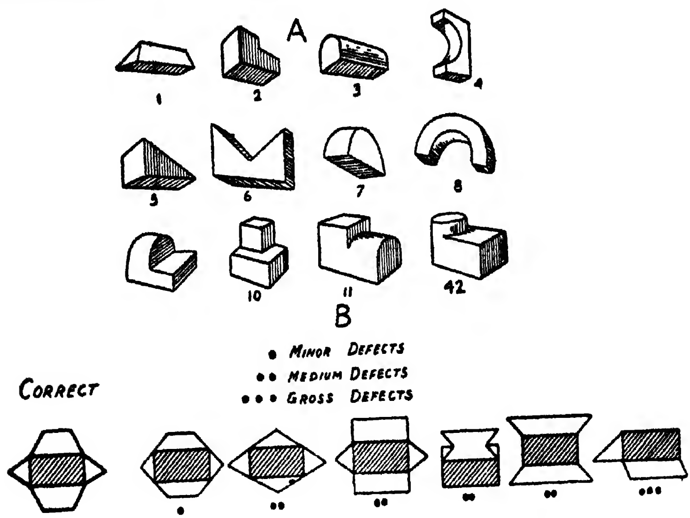


FIGURE 33. *Spatial Perception Test*
(After Rupp)

minutes are allowed for the completion of the test. The scoring is in terms of errors and the final score on this test is expressed on a 5-point scale according to the following classification: [35]

TABLE 29

ERRORS	SCORE
0	1
1–2	2
3–5	3
6–7	4
more than 7	5

Technical comprehension is measured by means of a series of blanks such as that illustrated in Figure 34. The question under 6 reads *"Which grip favors the most effective stroke with the hammer: L or R?"* In the case of 8 the question reads *"Which is wrong: A or B, and*

[35] Scores in each instance are grouped into a five-point scale in the proportions of 1: 2: 4: 2: 1.

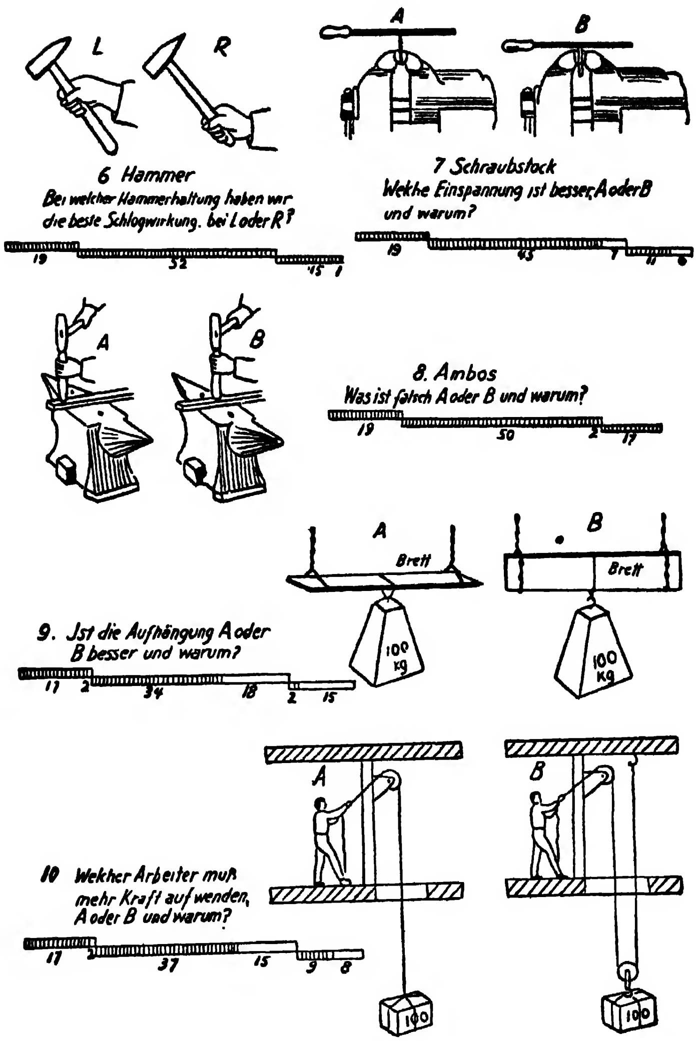


FIGURE 34. *Test of Technical Comprehension*
(After Rupp)

why?" Question 9 reads *"Which is the better way of hanging the weight: A or B;"* and 10, *"Which arrangement requires more effort on the part of the man: A or B, and why?"* The scoring for this test is in terms of correct answers. In this case again, as in the case of every other test, the final score is expressed in terms of a 5-point scale.

On Plate IV is shown one of the tests employed to measure *mechan-*

ical ability. In this case the subject moves the board, on which has been placed a sheet of paper, under the pencil attached to the horizontal arm of the apparatus. Employing this procedure the subject draws 4 vertical lines parallel to one another and a few simple designs. The problem is to control the board so that all lines will be straight and continuous. The time allowance is 15 minutes. Scoring is in terms of time as well as in terms of quality of performance.

In another test of mechanical ability, the subject is provided with a round piece of lead 8 cm. in length, and required to hammer it into a 4 sided bar, pointed at both ends, of the same length as the original

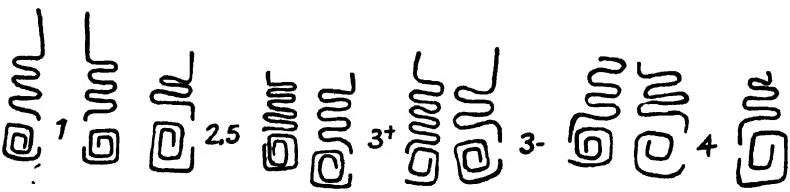


FIGURE 35. *Scoring Scale for Wire Bending Test*
(After Rupp)

round piece. The scores assigned to various final products are shown in Plate IV.

Among devices employed by Rupp and a number of other German investigators in testing apprentices in the metal trades is the *wire bending* test. In the procedure employed by Rupp the subject is given 2 pieces of wire 8 mm. in width and 50 cm. in length and required to bend them into the shapes shown on Figure 35, which shows a portion of the rating scale used in scoring the quality of the finished product.

The results of the series of tests is combined into a single score, likewise expressed in terms of a 5 point scale. The evaluation of these tests is illustrated in Figure 36, showing a comparison between final test scores and the shop performance of apprentices in the Siemens-Schuckert Works in Berlin. The solid dot represents the final rating on performance in the plant based on quality and quantity of work. The small circle represents the final score on the selection tests. The graph, which is of a type frequently employed by German investigators, presents the differences between scores on these two measures, each expressed in terms of a 5 point scale. The average difference in score is 0.58, whereas on the basis of chance it should be 1.2.

As a result of the policy of the firm in hiring the sons of those employed in the plant, a certain number of apprentices with low test scores (4 and 5, shown to the right of the heavy line) were hired. Only one of the 15 so hired obtained a score of 3 on performance in the plant. It is evident that the predictive value of this particular battery of tests

and the efficiency of this group of workers could be considerably improved through the rejection of all applicants making low scores on the tests.

Rupp has calculated the working time that could be saved through this more radical application of the testing method. Assuming 100 per cent to be the time required for the production of certain material in the plant by apprentices hired without regard for test scores, it is found that there was a decrease of 16 per cent in time required by those actually hired on the basis of test scores. If only applicants with

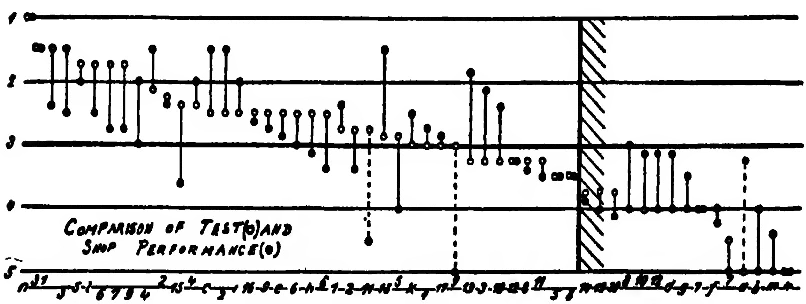


FIGURE 36. *Comparison of Shop and Test Performance of 53 Apprentices in Siemens-Schuckert Works, Berlin*

(After Rupp)

scores below 3 had been employed the gain in production time could be increased to 31 per cent.

Apprentice Selection by the Firm of A. Borsig-Tegel

Equally satisfactory results are reported by Hildebrandt,[36] who has employed a battery of tests in many respects similar to that used by Rupp in testing apprentices for another firm (Borsig-Tegel). These investigators disagree with respect to the relative value of tests of form perception and those of manual ability but, in spite of this difference of opinion with respect to individual tests, the results obtained by both are very similar. The character of Hildebrandt's findings are illustrated in Table 30, showing (a) the rank order of 30 machinist apprentices on the psychological tests, (b) ratings on quality of work furnished by foremen at the end of one-half year of service, and (c) the actual time taken for 14 standard projects completed in the work shop by apprentices during the first half-year of training.

A rating of 5 on quality of work is equivalent to *unusually good quality of production;* 3, *good quality;* and 1, *altogether unsatisfactory.* It is evident that there is very close relationship between foremen's

[36] H. Hildebrandt, *op. cit.*

TABLE 30

Evaluation of Tests for Machinist Apprentices

RANK ORDER ON SELECTION TESTS	SUPERVISORS' RATINGS		TIME—IN HOURS FOR 14 PROJECTS	
1	5		56½	
2	3		87	
3	4		79½	
4	3		58¾	
5	3		83	
6	5	37	37¾	794½
7	4		122	
8	3		114½	
9	4		83	
10	3		72½	
11	3		174½	
12	2		86	
13	3		66½	
14	2		95½	
15	2		88½	
16	3	27	97½	995½
17	3		97½	
18	3		88½	
19	3		111½	
20	3		89½	
21	3		94	
22	3		65	
23	2		146½	
24	3		107¾	
25	4		84½	
26	2	23	86¾	1024
27	2		82	
28	1		106	
29	2		133½	
30	1		118	

(After Hildebrandt)

judgments, actual production and performance on the tests. It is interesting to note that Group 2 of the apprentices (classified according to psychological test scores) spends approximately 25 per cent more time on work projects than Group 1. The differences between Group 3 and Group 2 are not so marked. It is important to note in this connection that, in general, apprentices in Group 3 were doing satisfactory work in terms of ordinary shop standards.

An analysis of the production of the entire group of apprentices in the course of 5 years leads Hildebrandt to conclude that the examination of apprentices prior to selection leads to a 11.6 per cent decrease in production time and a 14.3 per cent increase in quality as compared with a group hired without testing. An analysis of turnover statistics for years following the introduction of tests in 1920 shows a higher proportion of involuntary separations among apprentices with low than among those with higher test scores. The exact influence of test scores upon turnover for all apprentices cannot be determined, according to Hildebrandt, because of the political and social factors affecting turnover during the years under consideration—1919–1925.

The extent and usefulness of tests in the selection of apprentices in the metal trades are indicated in a survey, by Kellner,[37] of the experiences of a number of German industries with this type of examination. This investigator expresses the relationship between test scores and success of apprentices in the plant in terms of a percentage figure —70 per cent representing the lowest figure indicating a satisfactory relationship between test scores and proficiency.[38] Applying this figure, an agreement of 85.7 per cent is found between test scores and the performance of 14 apprentices employed by the Kabelwerk Oberspree plant of the German General Electric Company. In the Daimler Motor Works an agreement of 81 per cent between test performance and proficiency on the job is reported. In the Goerz plant of the Zeiss Organization, an 80 per cent agreement between the test scores and ratings in the plant is found in the case of 17 toolmaking apprentices. A number of other results of this same kind are reported by Kellner, who employs an ingenious calculating procedure to show that, on the whole, suitably selected apprentices can be expected to be 15 per cent more efficient than those haphazardly selected, at a gross saving of three hundred marks over a four-year apprenticeship period.

TESTING IN OTHER SKILLED AND SEMI-SKILLED JOBS

Experimental investigations with skilled workers, both in Europe and the United States, has not been limited to the selection of apprentices. In shoemaking,[39] garment making,[40] a variety of jobs in the

[37] H. Kellner, "Neun Jahre Prüferfahrungen in der Berliner Metallindustrie," *Ind. Psychot.*, 5 (1928), pp. 33–48.

[38] Kellner does not make clear how this figure is obtained. It represents apparently an attempt to express the coefficient of correlation in terms of per cent better than chance forecasting efficiency, but his treatment of results suggest that the transmutation is not in standard terms. In spite of this, it seems well to describe some of Kellner's findings employing the criterion which he sets up with 70 per cent as the minimum index of satisfactory relationship.

[39] T. Mayer and O. Sterzinger, *Die Berufseignung des Schusters*, Wien, Leipzig, 1926, pp. 52; H. Zirn, "Eine psychotechnische Eignungsprüfung für den Schuhmacher," *Psychot. Z.*, 6 (1931), pp. 65–80.

[40] W. Spielman, "Vocational Tests for Dressmakers' Apprentices," *J. Nat'l Inst. Ind.*

chemical industry[41] and in the manufacture of electric lamps,[42] acetylene welding,[43] crane operation,[44] printing,[45] and a variety of other jobs, experimental studies have been made. The extent of this

TABLE 31

YEAR	TOTAL NUMBER EMPLOYED	TOTAL NUMBER OF SEPARATIONS	PERCENTAGE OF SEPARATION
	Prior to use of psychological tests		
1925	4074	474	11.7
	Subsequent to the use of psychological tests		
1927	5678	346	6.9
1928	5830	351	6.02
1929	8688	280	3.2
1930	4782	139	2.9

(After Dellwig)

work, in Germany alone, is perhaps illustrated in a recent statement, by Dellwig,[46] that the Psychological Center directed by Poppelreuter has examined, between 1924 and 1931, over 12,000 individuals seeking placement in a number of plants served by this center. The examinations involved jobs as varied as machinist, electrician, pattern maker, crane operator, builder, etc.

Figures on labor turnover among foundry workers are cited by the same investigator as evidence of the value of the use of psychological

methods in the selection of helpers and workers in other occupational classifications. (Table 31.) Additional evidence is cited in many other studies of decreased costs and improved individual adjustment following the use of selection tests in this important section of the industrial sphere.

XIV. TESTS IN THE TRANSPORTATION INDUSTRY

The cost and social consequences of accidents in the transportation industry have made the selection of automotive vehicle operators an outstanding problem in vocational placement. Both in Europe and the United States numerous investigations have been undertaken for the development of tests as an aid in the selection of street car motormen, automobile operators, and locomotive engineers. In the development of these investigations the objectives of reducing the cost of energy consumption and training have been added to the original objective of eliminating accident-prone drivers. The chapter which follows is devoted to a brief historical account of studies in this field, to a description of apparatus employed, and to the citation of a few results which have been obtained in the use of tests in the selection of motor vehicle operators.

THE SELECTION OF MOTORMEN—THE PIONEER WORK OF MÜNSTERBERG

The earliest work in the scientific selection of motormen is the well known investigation of Münsterberg, undertaken in 1912, at the suggestion of the American Association for Labor Legislation.[1] His experimental work grew directly out of an informal meeting of men interested in electric railroading and psychology held in March, 1912, under the auspices of that Association, in the course of which the importance of considering the place of "human frailty" in accident causation was discussed. There was emphasized, possibly for the first time, the need for providing measures of the "mental qualities for a class of work in which life and limb and financial success are at stake," as a means of decreasing the number of accidents attributable to the human element in street car operation. Münsterberg decided, after careful observation, that the process which seems to be the "central one for the problem of accidents" was "a particular complicated act of attention by which the manifoldness of objects, the pedestrians, the carriages, and the automobiles are observed with reference to rapidity and direction in the quickly changing panorama of the street." In the avoidance of accidents

[1] "Psychological Tests for Accident Prevention," *Elec. Rlwy. Jour.*, (March 9, 1912), Vol. 39, No. 10, pp. 394–395; H. Münsterberg, *Psychology and Industrial Efficiency*, Cambridge, 1913, Chapter VIII.

"the ability to keep attention constant, to resist distraction by chance happenings on the street, and especially the always needed ability to foresee the possible movements of pedestrians and vehicles" were found by him to be of greatest importance.

The apparatus designed by Münsterberg to measure abilities of importance in avoiding accident consists of a black wooden box, covered by plate glass, over which there is a black velvet belt 8 inches in width. This velvet belt moves over two cylinders at the front and rear ends of the apparatus. In the center of the belt is a window 4½ inches in width and 2½ inches high.

Beneath the belt are placed 12 cards, each 4½ inches wide and 13 inches long. The card is supposed to represent a street. (Figure 37.) Two heavy lines, representing the street car tracks, divide the card vertically into 2 halves. The card is divided into small ½ inch squares each of which is considered as a unit. Lengthwise there are 26 units. The 26 squares which lie between the 2 heavy vertical lines are marked with the printed letters of the alphabet from A to Z. The four rows of squares on both sides of these are filled with black and red digits from 1 to 3. Digit 1 represents a pedestrian who moves just one step, that is, from one unit to the next; digit 2 a horse, which moves twice as fast, that is, two units; and digit 3 an automobile which moves three times as fast, that is, three units.

Black digits stand for men, horses, and automobiles which move parallel to the track and are therefore to be disregarded in looking out for danger. The red digits move from either side toward the track, and are therefore the dangerous ones. The subject is required to find as quickly as possible those points in the track which are threatened by red figures, that is, those letters in the 26 track units at which red figures will land, if they make the steps which their numbers indicate. Thus, a red digit 2 which is two steps from the track would land on the track, and therefore represents danger; a red digit 2 which is one unit from the track is to be disregarded, because it would cross the track and be out of danger. The same principle holds for all red digits.

When the front cylinder of the apparatus is turned by a metal crank, the velvet belt passes over the glass plate and the little window moves over the card, with its track and figures. The whole breadth of the card with its central track and its 4 units on either side is visible through the window over an area of 5 units in the length direction. The subject turns the crank with the right hand; the window slips over the whole length of the card; and one part of the card after another becomes visible. The subject simply has to call out the letters of those units in the track at which pedestrians and vehicles represented by the red letters would actually land if they took the number of steps indicated by the digit. At the moment the window has reached Z on the card the experimenter withdraws the card and the second becomes visible as a second window appears at the lower end of the belt. In this way the

subject can turn the crank repeatedly without stopping, until he has gone through the 12 cards. A spring beneath the card presses the lower card against the glass plate as the top one is removed. The score on this test is determined both by errors and by the time taken to observe the

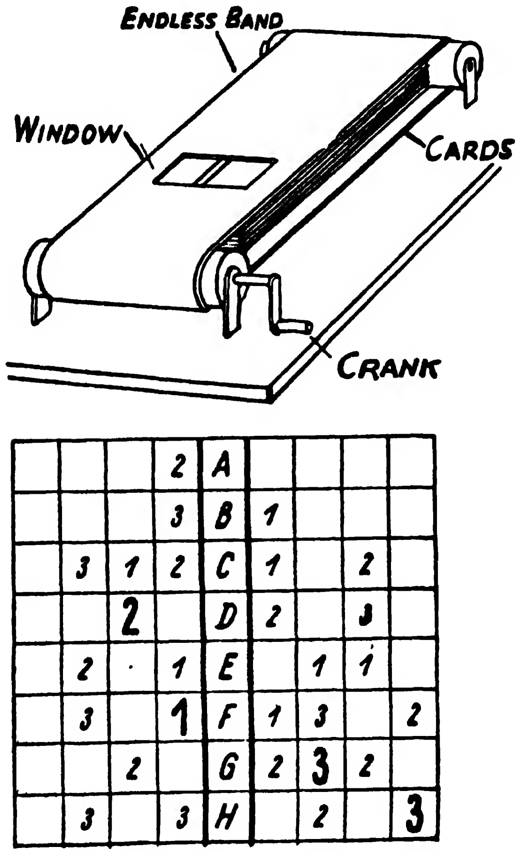


FIGURE 37. *Münsterberg Motorman Selection Test*
Heavy figures represent red digits
(After Münsterberg)

12 cards. The two are combined into a single score, inasmuch as the practical problem in street car operation, according to Münsterberg, is to combine speed with the smallest number of oversights.

The test was given by Münsterberg to a group of the best motormen in the service of a street railway company—men who had worked for 20 years practically without accidents; to a group of mediocre motor-

men; and to a large number of men who had only just escaped dismissal and whose records showed a large number of accidents. The exact number of cases is not stated. Number of accidents seems to have been the basis for the separation of the three groups. The results, according to Münsterberg, "show a far reaching correspondence between efficiency in the experiment and efficiency in the actual service." Moreover, "the tried motormen agreed that they really passed through that experiment with the feeling which they have on their car." He points out, however, that "the experience refers only to those sides of the motorman's mind which make him able to foresee danger points—the most essential factor in accident prevention," and that this test does not measure other mental traits, such as daring, ignorance of local conditions, etc., which may become causes of accidents.

In summarizing the results of his investigation Münsterberg makes it clear that it is still in the first stage, in need of large scale co-operation between science and industry in order to determine the desirable modifications and special conditions which may become necessary in making the employment of men partly dependent upon such psychological tests. Münsterberg's death on December 16, 1916, cut short further contribution from him in a field in which he was pre-eminently the pioneer.

Following his death Münsterberg's test was tried out by a number of other investigators. Gerhardt [2] reports satisfactory results in the selection of motormen from the use of a modified form of the Münsterberg apparatus. However, the failure to define criteria and to employ standard practices in test administration makes his findings of questionable validity. Fontègne [3] and Claparède report negative results from the application of the test to 30 subjects. Rupp [4] likewise obtained unsatisfactory results from the application of the test with modified stimuli card to 10 motor vehicle operators. Negative findings also came out of a trial of the Münsterberg test by the Milwaukee Electric Railway and Light Company. Although the results of this study were not available to the author, the opinion of the officers of the company who had participated in the study, were decidedly opposed to further work with this test.

STUDIES BY THE MILWAUKEE ELECTRIC RAILWAY AND LIGHT COMPANY

American investigations subsequent to the death of Münsterberg in 1916, and prior to 1920, included a study of non-test factors in selection by McCants and an analysis of the suitability of general intelligence

[2] P. W. Gerhardt, "Scientific Selection of Employees," *Elec. Rlwy. Jour.*, 47 (1916), pp. 943–945.

[3] J. Fontègne, *L'Orientation professionelle et La Determination des Aptitudes*, Paris, 1921.

[4] H. Rupp, "Untersuchung zur Fahrerprüfung bei der Deutscher Reichspost und bei der Städtischen Strassenbahnen der Gemeinde Wien," *Psychot. Z.*, 1 (1926), pp. 157–164, 199–220.

examinations for these purposes by McCants.[5] In 1920 the author undertook a further investigation of this problem for the Milwaukee Electric Railway and Light Company.[6] A preliminary step in this investigation naturally took the form of a complete analysis of the job, in the course of which the author went through the regular training course and operated a street car in every section of the city under a great variety of conditions. Observation and practice was supplemented by consultations with motormen, supervisors, and instructors. This study showed that Münsterberg's analysis of factors important in street car operation was altogether inadequate. The latter limited himself to an examination of the attentive factors in operation. The author's analysis showed that safety in operation involves not only attention, but selective muscular response to rapidly changing stimuli.

The degree to which a given motorman avoids accidents is, in the main, determined by his capacity to learn to associate a given response with a given situation and to give the appropriate response when faced with a similar situation. Sounding the bell at street corners, stopping at the traffic signal set against him, operating electric switches, decreasing speed when running by parked automobiles, are examples of such learned responses. The response which he gives is generally a complex one, involving the co-ordination of a number of muscles of arms and legs and of both sides of the body.

The safe motorman, the one who will be least likely to cause accidents, must *pay consistent attention and observe all that goes on in the street*. In addition, he *gives the proper selective co-ordinated response to the stimulus which he perceives*. The difference between the man who "gets rattled" and the man who "keeps cool" in an emergency is that in the case of the former, response is entirely inhibited or an incorrect response is exhibited, whereas the latter responds under all conditions with a correct reaction.[7]

THE VITELES MOTORMAN SELECTION TEST

The test devised by the author for predicting safety in operation includes four main parts: (Plate I.)

1. *Signal Board for Visual Stimuli,* placed at a distance of 20 feet from the subject. Scattered irregularly over this board are 7 square openings. (Figure 38.) Behind each is a 15 watt lamp. These lights are wired so as to flash at regular intervals, all 7 lights flashing at one time. Each of the lights marked 1 and 4 can be cut out. The failure of

[5] M. McCants, "Tests Used in Selecting Employees," *Elec. Rlwy. Jour.*, 60 (1922), pp. 710–715.

[6] M. S. Viteles, "Research in the Selection of Motormen: Methods Devised for the Milwaukee Electric Railway and Light Company," *J. Pers. Res.*, 4 (1925), pp. 173–199.

[7] In addition to operating safely the motorman has other responsibilities. He must maintain schedules; use energy economically; maintain cordial public relations; be prompt and regular in reporting for work; etc. These other factors were considered in the study undertaken by the author, but will not be discussed in this present chapter.

aperture 1 to be illuminated as the remaining six lights flash on constitutes *Signal 1.* The failure of aperture 4 to be illuminated as the remaining six lights flash on, constitutes *Signal 2.* With each of these signals is associated a stated response on the reaction stand.

2. *Signal Board for Auditory Stimuli,* including a bell and a horn. With each of these a definite reaction is associated.

3. *Reaction Stand,* upon which are mounted two handles (see Figure

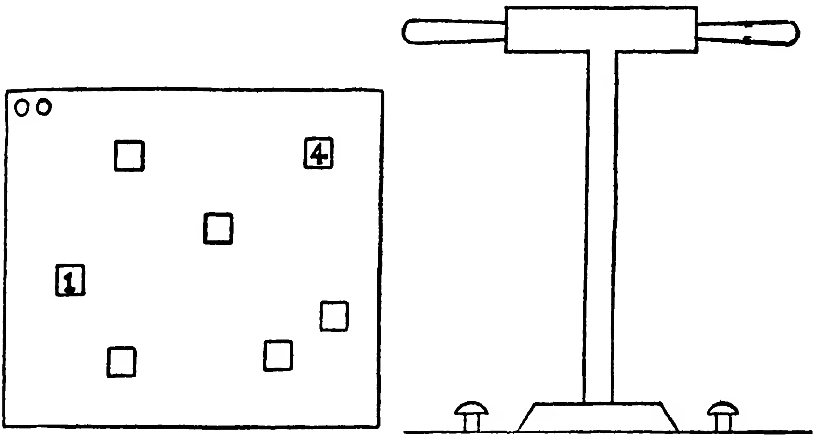


FIGURE 38. *Viteles Motorman Selection Test*
Signal Board for Visual Stimuli *Reaction Stand*
(*After Viteles*)

38) that can be moved backward and forward from a central point. At the foot of the stand are two pedals, representing two foot pedals on the front end of a street car.

4. *A Distraction Signal.* On the original test this consisted of a 250 watt lamp placed about 10 feet to the right of the *signal board for visual stimuli* and somewhat in front of it. In later forms of the test this was changed to an arcing contact, placed above and somewhat behind this board.

Administration of This Test

The administration of the test calls for (1) a *training period,* and (2) a *testing period.* Approximately 35 minutes are required for the complete examination. During the *training period* the subject is taught the appropriate response to each of the four signals—two visual and two auditory. For example, he is taught that in response to Signal 1 he is to pull both handles toward him and step on the left pedal. For each stimulus there is a similar standard reaction involving either movements of the two hands alone or combined hand and foot move-

ments. During the training period the subject is automatically informed whether his response is right or wrong by the illumination of small red and green lights placed on the upper left hand corner of the *signal board for visual stimuli,* and by the illumination of the darkened apertures in the case of Signals 1 and 2. In this way he can observe and correct his errors.

A definite training program has been outlined. The program is standard for each individual with respect to the method of training but not with reference to the time spent in training. The amount of training given to each applicant depends upon the speed with which he attains *definite standards of learning which have been experimentally established.* Training is continued until these criteria have been satisfied. Although the length of the training periods of different individuals differ, there is a minimum training applying to all subjects.[8]

Evaluation of the Test

In a preliminary study by the author made in the fall of 1921 the performance on the *Viteles Motorman Selection Test* of 85 motormen hired during 1920 was compared with ratings on safety given by a group of motorman instructors and supervisors, each motorman being rated as *very safe, safe,* or *fairly safe* by each supervisor and motorman instructor familiar with his operation. Figure 39 shows the degree of *Safety* in car operation plotted as ordinates against the number of mistakes on the *Motorman Selection Test* plotted as abscissae. The figure placed on the ordinate before the rating shows the percentage of supervisors and motorman instructors giving the man the indicated rating. For example, the results of a man who is rated as *Safe* by two supervisors and as *Fairly Safe* by two others would be placed on the line marked $\frac{\text{50 per cent Fairly Safe}}{\text{50 per cent Safe}}$.[9] The figures on the abscissae give the number of mistakes on the *Motorman Selection Test. Few mistakes on the Motorman Selection Test represent a good score; many mistakes represent a poor score.*

A study of the figure shows a tendency on the part of those rated as Fairly Safe by a majority of supervisors to grade low on the Motorman Selection Test and for those whose ratings are in the direction of Very Safe to grade high in this test.

In spite of this finding, it was felt that the tests could not be adopted for use in selection until a more satisfactory criterion of safety in operation could be obtained, the conclusion being drawn that the rat-

[8] M. S. Viteles, "Research in the Selection of Motormen," *J. Pers. Res.,* 4 (1925), pp. 179–181.

[9] In cases where ratings lay between the values given, the results were recorded on the line indicating the value closest to the exact value. For example, the results of a man who was rated as *Safe* by 66⅔ per cent of the supervisors who rated him, and as *Very Safe* by the remaining 33⅓ per cent would be recorded on the line for $\frac{\text{75 per cent Safe.}}{\text{25 per cent Very Safe}}$

ings of motormen instructors and supervisors cannot be accepted as satisfactory for a final check on the validity of this test. It was decided that the next step in this study should take the form of careful evaluation of ratings, and the preparation of more objective criteria of success as a basis for a further evaluation of the test.

Such a follow-up study has been made by Shellow, who has carried

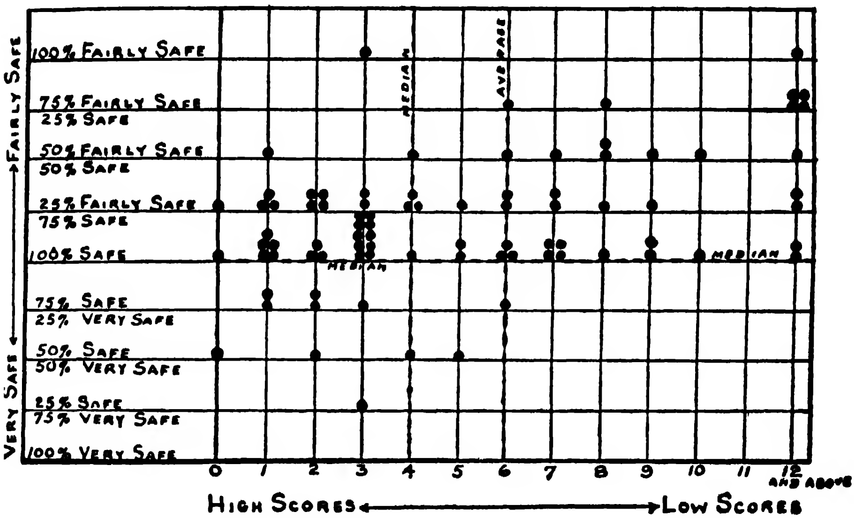


FIGURE 39. *Comparison of Ratings on Safety with Scores on Viteles Motorman Selection Test (85 cases)*

(After Viteles)

on the work started by the author at The Milwaukee Electric Railway and Light Company.[10] The procedure for administering the test has remained practically the same as that described above, although modifications in the operation of the test, permitting automatic recording of performance and of reaction time, have been introduced by Shellow and in a still later revision of the test by the author (illustrated on Plate I). The character of Shellow's evaluation of this test, involving a comparison of men hired prior to testing (1924) and subsequent to testing (1925), is shown in Figure 40.[11]

The most significant feature of this chart is the reduction shown in the number of men discharged because of accidents (the black sector) —a decrease from 14.1 per cent in 1924 to 0.6 per cent in 1925. Aside from this there has been a marked reduction in turnover in this organi-

[10] S. M. Shellow, "Research in Selection of Motormen in Milwaukee," *J. Pers. Res.*, 4 (1925), pp. 222–237.

[11] J. A. Dewhurst, "Personnel Selected and Trained in Milwaukee on Scientific Basis," *Elec. Rlwy. Jour.*, 67 (1926), pp. 624–629.

zation reported by the author. The test with which these results were obtained is still in use and giving highly satisfactory service in the selection of motormen who can efficiently and safely operate motor vehicles and in the re-adjustment of experienced operators involved in accidents.[12]

EUROPEAN STUDIES IN THE SELECTION OF MOTORMEN

The first edition of Münsterberg's *Psychologie und Wirtschaftsleben* appeared in Germany in 1912. This account of his American experiment

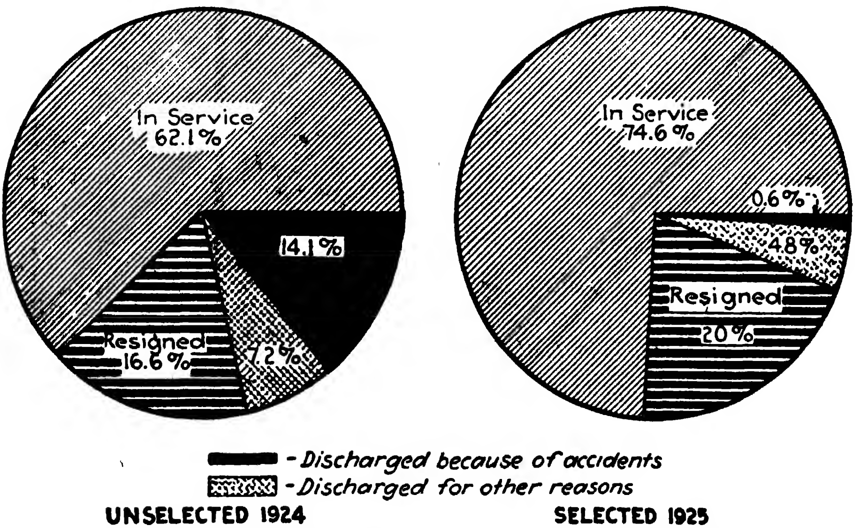


FIGURE 40. *Tangible Results from the Use of Scientific Methods in the Selection of Motormen*

(*After Shellow*)

is the first reference in German literature to the use of tests for the selection of motormen. Piorkowski,[13] writing in 1915, criticizes Münsterberg for his failure to test motor responses as well as attention qualities in his testing program for the selection of motormen. He points out that an individual may be perfect from the point of view of the ability to attend to a series of stimuli and still be deficient in the capacity to give the selective responses, a capacity which is most important in the avoidance of accidents. "It is not enough," he writes, "that the motorman pay consistent attention and that he does not fatigue easily;

[12] See Chapter XVIII.
[13] C. Piorkowski, "Beiträge zur Psychologischen Methodologie der Wirtschaftslichen Berufseignung," *Z. Ang. Psych.*, Beiheft No. 11, Leipzig, 1915, p. 106.

he must also be able to react correctly to quick and unexpected incidents." Similar criticism is made by other German investigators, and the measurement of selective responses characterizes practically all of the tests which have been devised for use in the selection of motormen in that country. The insistence upon measuring motor responses represents, in part, the influence of investigations which had already been made in the selection of aviators, chauffeurs, etc.

Studies by Stern and Sachs

Experiments in the selection of motormen in Germany were undertaken almost simultaneously by a number of investigators.[14] Among the earliest is an investigation undertaken by Stern,[15] in 1917, who gave an attention test to 6 women applicants for employment as street car drivers. This preliminary investigation served only to indicate more clearly the nature of the problem and to suggest the steps to be followed in a second investigation made possible by a special grant from the Government to the Hamburg laboratory for this purpose. For this second study, started by Bobertag and completed by Hildegard Sachs, a special apparatus was designed to test distribution and duration of attention to varied stimuli and the consistency of responses to expected and unexpected stimuli, some of which require a response and others of which do not. The subject stands before an endless black belt, which moves continually toward him, representing the tracks as he sees them from the front platform of the moving car. Single holes representing pedestrians, and double holes representing vehicles are cut in the belt. Each of these, when illuminated from below, is considered as a signal demanding reaction on the part of the subject. The holes can be illuminated unexpectedly in four different sections of the frame over which the belt runs. The subject's reaction to each signal is conditioned upon the distance of the signal from him, whether he responds with a pedal (foot), or with the brake (right hand), or with the emergency brake (left hand) depending upon the distance of the signal both in the case of the single light (pedestrian) and double light (vehicle). Moreover, unexpected stimuli in the form of lights placed at the sides of the room, at varying distances from the subject, also call for reaction on his part. In addition there is a colored aperiodic light, the flashes of which the subject must count. The examination, which takes 20 minutes, lasts long enough, according to the investigator, to introduce the element of fatigue.

At the time of the first report (1920) the test had been given to 20 motormen, 10 employed by the Hamburg Street Car Company, and 10 employed by the Hamburg Altona Central Station. In both cases test results were compared with descriptive judgments of the efficiency

[14] Experiments in this field are described in M. S. Viteles, "Research in Selection of Motormen: Survey of the Literature," *J. Pers. Res.*, 4 (1925), pp. 100–115.

[15] W. Stern, "Über eine psychologische Eignungsprüfung fur Strassenbahnführerinnen," *Z. Ang. Psych.*, 13 (1918), pp. 91–104.

of these men furnished by the street railway companies. In the case of the first 10 motormen there is a disagreement between test results and efficiency rating in the case of only 1 man. In the second investigation ratings agree only in the case of 5 men. An analysis of the apparent disagreement in the case of the other 5 men leads the author to conclude that only in the case of 1 man is there a real disagreement which can be ascribed to the failure of the test as a diagnostic instrument.

Tests used by the Greater Berlin Tramway Company

Among the more important German studies in the selection of motormen is one conducted by Tramm [16] of the *Greater Berlin Tramway Company*. Experimental work with tests for the selection of motormen was first started by this company in February, 1919. Following a preliminary investigation a series of tests, including tests of *fear control, vision, knowledge of regulations,* and *reaction in times of danger,* was given to 1035 ex-drivers upon their return from the World War. On the basis of their scores on these tests 87 per cent were classified as "satisfactory"; 6.5 per cent, as "not satisfactory"; and the remaining 6.5 per cent, as in need of additional training. In July, 1919, a battery of tests was set up in a newly erected testing room, and has since been used in the selection of motormen.

The tests used by the Greater Berlin Tramway Company require that the subject be placed on a driver's platform fitted with special arrangements for ordinary and frightening light and sound signals. Before the test the candidate is instructed in the operation of the controller and brake levers, and in the meaning of signals. In the course of the test these signals are given suddenly. Upon their appearance the candidate is expected to perform the operation in which he has been trained.

To test how a candidate will behave in the event of sudden danger, the man is placed before a controller handle and, while he is practicing with it, he is frightened by a sudden report, a short-circuit flash passing before his face. Another test of cold-bloodedness or "nerve" is provided by a board painted to represent a miniature track. Electrically lighted obstacles suddenly appear on the track, and the "presence of of mind" of the prospective motorman is gauged by the rapidity with which he turns his dummy controller handle to the off position and applies his brakes.

The battery includes tests of visual acuity, color blindness, and night vision. "Steadiness of hand" is tested by requiring the subject to seize the handles of two vertical rods which fit with a certain amount of play into slots in a metal plate. As long as he keeps his hands quiet, the circuit of an electric bell is interrupted. However, as soon as his hands begin to tremble ever so little, these rods will touch the edges of the

[16] K. A. Tramm, "Die Auswahl und Ausbildung des Fahrpersonals für Strassenbahnen auf psychotechnischer Grundlage," *Verkehrstechnik*, 36 (1919), pp. 25–28; *Prakt. Psy.*, 1 (1919), pp. 18–33; and "Die Bewahrung des psychotechnischen Prüfverfahren für Strassenbahnführer, *Ind. Psychot.*, 1 (1924), pp. 36–42.

slots, thus actuating the bell, and the candidate must try to keep the rods quiet so as to silence it.

A test with one crank designed like a controller crank, and another like a brake lever, both connected so that they turn a disk independently, is used for the same purpose. The applicant is asked to turn the disk by one crank and then by the other into the various travelling positions, without touching the edges of the slot. Whenever he fails to comply with this request, an electric bell is sounded.

Tests of judgment in operation and of technical intelligence are also included in the series. The administration of the entire battery requires approximately one and a half hours.

Studies have been made of the reliability and validity of individual tests. The "critical" reliability of the entire battery is, according to Tramm, "85 to 90 per cent." In a preliminary evaluation of the tests an experimental group of 50 apprentices who were tested before selection was compared with a group of 50 apprentices hired without the psychological examination. In the first year of employment the motormen in the control group, that is, those who had not been examined, had 50 per cent more accidents than those in the experimental group who had been examined and had passed the psychological test. In the second year of employment the experimental group again had 40 per cent less accidents than the control group.

The usefulness of the test is suggested in a report by the Greater Berlin Tramway, published in 1922, which attributes a reduction in the number of serious accidents from 1.6 to 1.1 and of minor accidents from 42 to 29 per 1,000,000 kilometers, a decrease of 50 per cent in the length of training, a marked reduction in the use of current and the cost of repair to the use of psychological tests, improved method of training, and a change in organization based upon psychological principles. According to Piorkowski, an economy of over 12,000,000 marks (July, 1922) had been achieved in one year through the reduction of these costs.[17]

The Paris Combined Transport Services

Psychological studies of street car operation in Paris date from 1908 when J. M. Lahy was commissioned to undertake a study of energy consumption.[18] In 1921 a study of tests devised by Lahy was undertaken with the co-operation of the Paris Combined Transport Services which provided an experimental group of 200 motormen. The discovery of agreement between test results and ratings on operation led to the establishment of a testing center, under the direction of Lahy, in which both motormen and bus drivers are tested.

[17] M. S. Viteles, "Psychology in Business in England, France and Germany," *Ann. Amer. Acad. Pol. Soc. Sci.*, 110 (1923), pp. 207–220.

[18] J. M. Lahy, *La Selection psychophysiologique des travailleurs; conducteurs de tramways et d' autobus*, Paris, 1927, pp. 227.

The battery used by Lahy includes, like that of Tramm, a series of analytic tests supplemented by a few of the analogous type. Tests of distributed attention, reaction time, motor suggestibility, emotionality, immediate memory, perception of speed, etc., appear in the battery. To test the applicant's ability to estimate speed, the candidate is seated 10 or 12 feet from, and at right angles to, a long narrow bench on which are 3 upright pointers indicating vehicles placed at different distances apart. These are set in motion, and the candidate is required to make a rapid estimate as to the point at which one will overtake the other or where one will meet the other. A graduated scale on the bench readily enables him to state the point at which he expects this to occur, but its exact location is by no means easy. The promptness and accuracy of the candidate's reply presumably give a measure of this ability.

During the candidate's *training* period, he is put through a test on a platform placed immediately in front of a large white screen. On this screen is projected a street scene taken by a cinema camera from the platform of a moving street car. The road winds; people cross in front; a taxi darts out from a side street; a man steps right in front of the car. The pupil manipulates levers or pedals as required, and his methods of reacting are accurately recorded on registering machines connected directly with the controls on the platform. The way in which he applies the brakes, for instance, when a vehicle is supposed to cross his track, is recorded. He may apply a steady even pressure, or perhaps grasp his controls convulsively and apply his brake too suddenly. By a comparison of such records with those obtained from a driver of known ability under the same conditions, a forecast is made of the candidate's degree of suitability for street car operation.

As a result of the use of this battery of tests the percentage of street car and bus drivers dropped for incompetency either during or subsequent to training has been reduced from 20 to 3.4. This results in an annual economy of 150,000 francs. Drivers hired subsequent to selection are responsible for 16.5 per cent fewer accidents than those not tested prior to hiring. This represents an annual saving of 1,300,000 francs.[19]

WORK SAMPLE TESTS IN THE SELECTION OF MOTOR VEHICLE OPERATORS

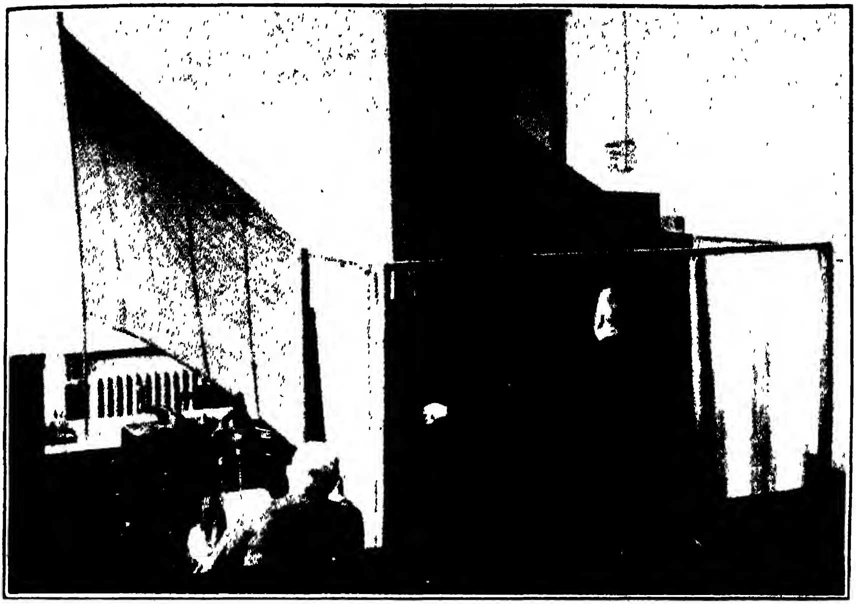
Recent developments in the selection of motor vehicle operators in Europe show a tendency toward the use of more closely analogous and work-sample tests. This is a part of the general movement toward a type of examination which stresses the totality of personality displayed on the job under conditions characteristic of the work.[20] This tendency is somewhat reflected in an apparatus devised by Rupp,[21] which makes

[19] *Ibid.*, pp. XI–XII.

[20] M. Nier, "Der Mensch als Wirtschaftsfaktor im Verkehrsbetriebe; seine Eignung und Anlernung," *Ind. Psychot.*, 8 (1931), pp. 48–49.

[21] H. Rupp., *op. cit.*, pp. 157–164; 199–220.

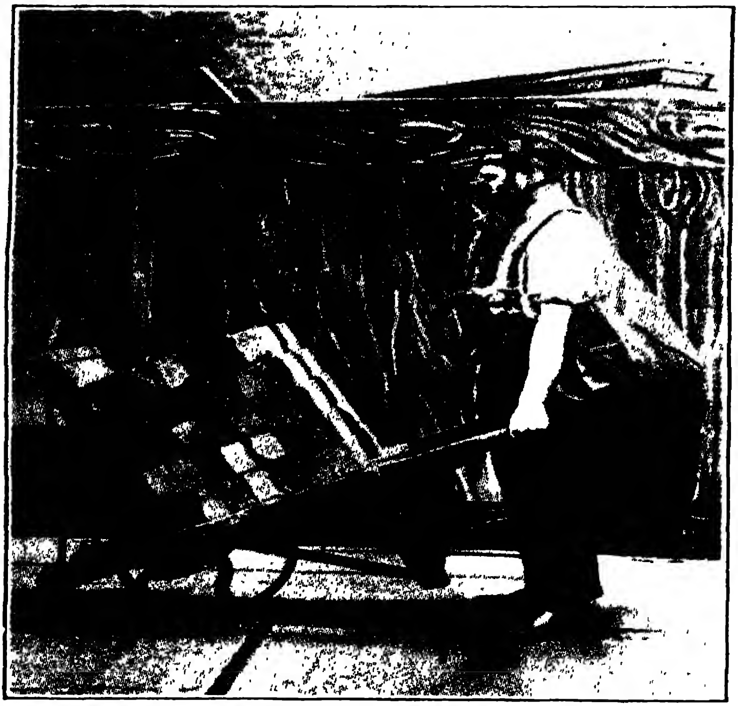
PLATE V



Apparatus for Practice and Recording Practice in Street Car Operation

(After Nier)

PLATE VI



Experimental Set-Up for Measuring the Physiological Cost of Work

(After Crowden)

use of a print showing streets winding between rows of houses, over hills, through woods, etc., attached to a slowly rotating drum. The subject is required to thread his way along the street (for 30 mins.), using a pencil manipulated by steering wheel, to indicate the pathway. The problem is to avoid obstructions, to take curves without running into the sidewalk (as indicated by the pencil mark), to respond to incidental signals, etc.

An even closer approach to the actual driving situation is favored by Poppelreuter [22] who has used a miniature "elektromobil," large enough to hold the operator, to analyze individual tendencies in the operation of a motor vehicle. Such behavior tendencies—a reflection of the way in which "speed" and "accuracy" are integrated—are revealed, according to Poppelreuter, in the course of learning how to operate the elektromobil under simple traffic conditions, and in a laboratory test in which the subject is required to steer a pencil across a moving paper representing an approaching street.

Poppelreuter distinguishes among such driving types as "direct," "worried," "differential," each of which can be recognized by a skilled observer as the subject practices in the elektromobil and through an evaluation of records on the laboratory apparatus. Although no substantiating data is presented, the investigator claims satisfactory results in three separate studies.

The "totality method" in the selection of motor vehicle operators finds its most recent expression in a procedure devised by Nier who requires the subject to react on dummy control, etc., to visual and auditory stimuli recorded on a talking film (Plate V), which duplicates essentially those appearing in street car operation. Every response of the subject is recorded on a master sheet, attached to a moving drum, which permits a comparison of actual response with optimal reaction. (Figure 41.) Training under these conditions becomes, according to Nier, a procedure by which individuals who at first seem to have inadequate competency for safe and economical operation can be developed into satisfactory operators.[23] Substantiating data on reduction of accidents and decreased energy consumption is offered in defense of this technique which is based, as is apparent, on the assumption that training serves to eradicate individual differences.

THE SELECTION OF AUTOMOBILE OPERATORS

A few of the tests described above have been used in the selection of auto drivers as well as motormen. In addition, a number of studies have been limited to this type of motor vehicle operation. The earliest—and most extensive of these—is a project developed by Moede

[22] W. Poppelreuter, "Beitrag zur Analyse der Fahrer-Lenker-Tätigkeit und deren Begutachtung," *Psychot. Z.*, 4 (1929), pp. 53–64.

[23] M. Nier, *op. cit.*, p. 96.

and Piorkwiski [24] during the World War, in which 24,000 drivers were examined in 14 centers. The test involved selective response to a series of lights, noises, etc. This is perhaps the original test of this type, although other investigators have independently adopted the same pro-

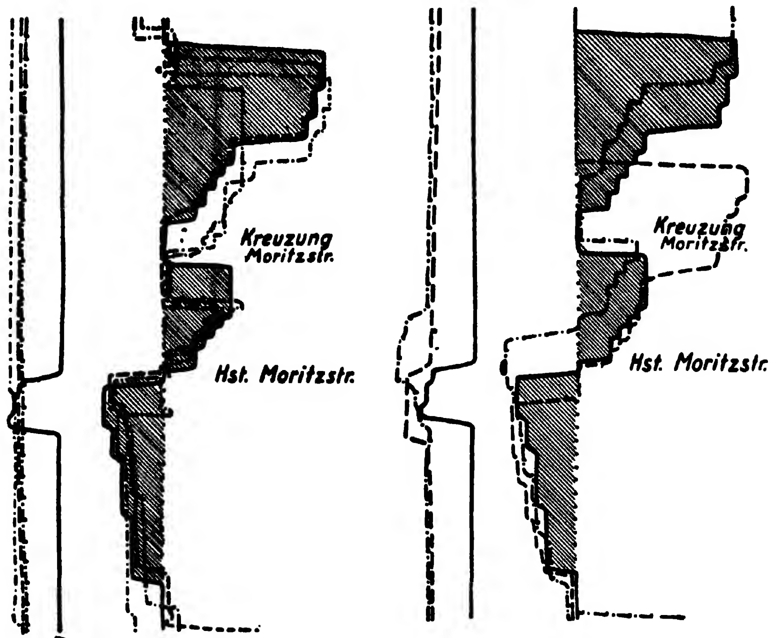


FIGURE 41. *Learning Curves in the Operation of Motor Vehicles (After Nier)*

cedure in testing drivers of motor vehicles. No direct evidence on validation is presented although one of the investigators reports that 20 per cent of subjects submitted to the test were rejected as incompetent.

Experiments with Taxicab Drivers

A number of studies of automobile operation have been concerned with taxicab drivers. Among these is an investigation by Snow undertaken in approximately 1925 for the *Yellow Cab Company of Chicago.*[25] The study started with a job analysis of taxicab operation and

[24] W. Moede, "Fahrerprüfungen Kraftfahrer-Eignungsprüfungen bein deutschen Heere, 1915–1918," *Ind. Psychot.*, 3 (1926), pp. 23–27.
[25] A. J. Snow, "Tests for Chauffeurs," *Ind. Psych.*, 1 (1926), pp. 30–45.

a survey of accident records of 3000 drivers over a 6 month period. As a result of this drivers were classified into "accident groups," according to frequency, and each group was in turn studied. Through this survey and by interviewing men involved in accidents, accidents were classified into types, such as those caused by *recklessness, carelessness, emotional instability, lack of foresight, physical defects,* etc. It was then undertaken to detect men likely to have each of these different types of accidents. The tests ultimately developed for this purpose included the following: (1) *intelligence test,* (2) *emotional stability* (fear-reaction-time) *test,* (3) *recklessness test,* (4) *carelessness test,* (5) *simple reaction test,* (6) *multiple reaction test,* (7) *judgment of speed and distance of moving objects,* (8) *muscular resistance test,* and (9) *fatigue test.*

At the time of the investigator's report (in 1926), only the "intelligence" and "emotional stability" tests had been satisfactorily standardized and evaluated. In one study the investigator gave these two tests to 311 applicants and predicted, in a report to the officers of the company, which of these new employees would have most accidents and which would not remain long in the company's employ. The Legal Department kept a record of the history of this group for a period of 10 weeks. The history of this group and the percentage satisfactory prediction made on the basis of the examination are shown in Table 32. The effect on the accident record of the entire company operation through the use of these two tests is shown in Figure 42.

At the time this study was reported the investigator was undertaking an ambitious program for the further evaluation of these tests and for the standardization of the remaining tests in the battery. However, no further data has been made available, presumably by reason of the investigator's separation from this company and the discontinuance of the work.

Another investigation in the field of taxicab operation has been reported by Wechsler [26] who has made use of a battery including (1) a group paper test (*It*), measuring *general intelligence,* and (2) an individual performance test (*D* and *De*), intended to measure the driver's *alertness of attention, carefulness,* and *quickness of reaction* under distracting stimuli. On this test the subject is seated in a dummy car and instructed to react in a stated way to lights of different colors flashed at irregular intervals. Reactions are automatically recorded on electric counters which total each type of response separately. The number of correct responses gives an index of alertness and speed of reaction, while the number of errors constitutes a measure of carelessness. The duration of this test is 15 minutes.

The tests were validated by comparison of scores (35 cases for *D* and *De* test; 135 cases for *It* test), with *number of merits* received

[26] D. Wechsler, "Tests for Taxicab Drivers," *J. Pers. Res.*, 5 (1926), pp. 24–30.

over a "given period of time," *number of accidents* during the same period, *average daily revenue*, and *revenue per cab-mile*.

The performance test (*D* and *De*) was found to be the most effective in selecting men having the fewest number of accidents. For example,

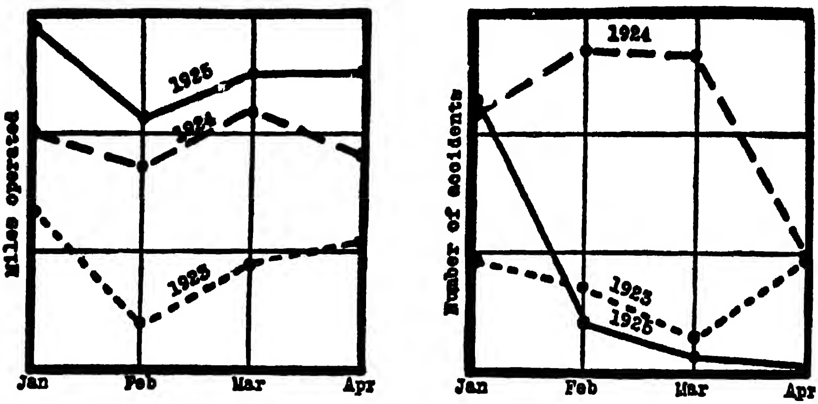


FIGURE 42. *Reduction of Taxi-Cab Accidents Through Scientific Selection*

A. *Comparative taxicab miles in Chicago. This shows the increase in business, or miles of cab operation by the Yellow Cab Company of Chicago in the first four-months periods of 1923, 1924, and 1925.*

A comparison of this chart with B. shows that, although the cab mileage showed a large increase, a proportionately much greater decrease in the number of accidents, particularly between 1924 and 1925, occurred.

B. *Taxi-cab accident rate during first four months of three years. The rapid and continuous drop in 1925 began immediately following the application of psychological tests to all applicants for driver jobs beginning January 1. During January only 400 out of 5,000 employees had been selected by tests but by the end of April, practically half of the drivers were tested men.*

(*After Snow*)

men failing on this test (having 5 or more errors) averaged 3.0 accidents per man *over a given period* as compared with 1.3 accidents per man of those who passed the test: 46.1 per cent of the men having 0 errors on the test had no accidents during this period, while 18.8 per cent of those having 1 to 3 errors had no accidents, and only 12.5 of those having 4 or more errors on the test had no accidents during this period. Similar results were revealed by comparing the drivers' scores and their superintendents' ratings. Those rating high on carefulness and safety in operation generally made the best test scores.

Those drivers with the greatest number of accidents were found to

have the slowest reaction time on the performance test. Men with the fastest reaction time tended to have a great many accidents. This was interpreted as an indication that those who are very quick are liable to take chances because of over-confidence, and thus risk accidents.

TABLE 32

CLASSIFICATION	NUMBER OF MEN EMPLOYED	MEN NEVER STARTED TO WORK	MEN THAT DROPPED OUT	STILL WORKING	ACCIDENTS: CARELESSNESS GROSS NEGLIGENCE	ACCIDENTS: QUESTIONABLE	ACCIDENTS: "NO LIABILITY"	MEN THAT HAD ACCIDENTS *	MEN THAT HAD MORE THAN TWO ACCIDENTS *	AVERAGE NUMBER OF ACCIDENTS PER MAN *	PERCENTAGE OF MEN THAT HAD ACCIDENTS *	PERCENTAGE OF MEN THAT HAD MORE THAN TWO ACCIDENTS *	PERCENTAGE OF MEN THAT QUIT *
Unsatisfactory Group	34	8	5	21	26	7	9	17	10	1.00	64	38	29
Group That will Not Stay Long	19	1	6	12	3	0	2	6	0	0.16	33	0	33
Satisfactory Group	258	10	50	198	50	19	24	84	32	0.20	33	12	20

* This tabulation does not include accidents which are "questionable" or "no liability."

(After Snow)

In comparing the group paper test scores with earnings, it was found that men having higher test scores tended to have greater daily revenue up to a certain point. Revenue began to decrease in the case of men making the highest scores, indicating that a man of superior intelligence who takes to cab driving as a profession is likely to have some special limitations. When test scores were compared with revenue per cab-mile it was found that on the average there were two inefficient drivers among the men making low scores to every one among those making high scores.

In reporting his findings the investigator states that in the analysis of results only the scores of the "old" men or such samples of them for which there were available "sufficiently complete" records were used.[27] Inasmuch as 250 men were tested, and only 135 included in the evaluation of *It* test and 35 in the evaluation of *D* and *De* test, it is evident that, particularly in the case of the latter, there has been a good deal of unexplained selection of cases. Moreover, the investigator gives no indication of the length of the "given period" considered in the evaluation of accidents, earnings, etc.—an inexcusable omission in the presentation of scientific data on vocational selection.

Among other studies of taxicab operation is an investigation by Moss and Allen,[28] who included taxicab drivers in a group of subjects in-

[27] *Ibid.*, p. 26.

[28] F. A. Moss and H. H. Allen, "The Personal Equation in Automobile Driving," *J. Soc. Auto Eng.*, 16 (1925), pp. 415–428.

vestigated for the purpose of determining reaction time under operating conditions. The author has standardized his Motorman Selection Test for use in hiring taxicab drivers, but the evaluation data is not available for publication.

THE EXAMINATION OF OTHER TRANSPORTATION WORKERS

In contrast to the United States, where the railroads appear to be somewhat backward in adopting improved selection methods, the railways of Europe—particularly in Germany and Russia—have been among the first to make use of psychological tests in selecting locomotive engineers, yardmen, repairmen, station employees, etc. Although space does not permit a description of methods and results in this field, it is interesting to note that tests for locomotive engineers have been in continual use for the State Railway of Saxony since 1917, with extremely satisfactory results.[29] Tests for locomotive engineers resemble those used in the examination of motormen and automobile operators, although material and methods are adapted to the steam railway situation. Other railway systems have followed the State Railway of Saxony in adapting these procedures and have extended them to other employees so that at the present time in Germany there are numerous centers participating in the examination of railway employees.[30]

[29] A. Schreiber, "Das Prüflaboratorium für Berufseignung bei den Königlich Sächsischen Staatseisenbahnen," *Z. Ver. D. Ing.*, 1918, pp. 446–54. See also *Prakt. Psych.*, 2 (1921), pp. 232–239; A. Gläsel, "Von der Dresdener Prüfstelle der Reichsbahn," *Prakt. Psy.*, 4 (1923), pp. 337 ff.

[30] R. Couvé, "Psychotechnische Eignungsprüfung von Eisenbahnverkehrsbeamten," *Ind. Psychot.*, 1 (1924), pp. 22–29; *Die Psychotechnik im Dienste der Deutschen Reichsbahn*, Berlin, 1925; C. Heydt, "Eignungsuntersuchungen für Eisenbahnbeamte der Assistentlaufbahn und des Stellwerkdienstes," *Ind. Psychot.*, 3 (1926), pp. 367–72; "Eignungsuntersuchung und Personalwirtschaft bei der Deutschen Reichsbahn," *Ind. Psychot.*, 7 (1930), pp. 136–142; B. Schwarze, *Die Personal Ausbildung bei der Deutschen Reichsbahn*, Berlin, 1928, pp. 742.

XV. TESTS FOR OFFICE OCCUPATIONS, TECHNICAL AND SUPERVISORY EMPLOYEES

TESTS FOR OFFICE OCCUPATIONS

A large proportion of early investigations on the use of tests in vocational selection in the United States was concerned with tests for office occupations. In 1924 Kornhauser and Kingsbury felt free to write that "greater progress has been made in the use of selective tests for office occupations than for any other class of vocations." [1] More recently there has been an apparent dearth of interest in such tests, following possibly from difficulties in developing satisfactory objective criteria which face the investigator in this field.[2] In general, as Anderson [3] has pointed out, amount of work and number of errors are the only available objective measures. In most cases these are difficult to obtain because employers rarely keep such records in the case of clerical workers. As a result, investigators have had to depend upon ratings by immediate supervisors. This criterion is generally unsatisfactory. It is particularly unsatisfactory on the office job, where actual efficiency at work is so easily over-shadowed by personal qualities of the worker, which impress the supervisor, although they play little or no part in determining proficiency. Whether or not this difficulty has discouraged investigators, it has had a most marked adverse effect upon the validity of results obtained in research programs on office jobs. However, in spite of this and in spite of current lack of interest in this field, progress has been made in the development of tests for office occupations. Such tests may be broadly classified into two groups: (1) *general clerical tests,* and (2) *tests for specific occupations.*

GENERAL CLERICAL TESTS

The general clerical test is designed to measure abilities which are presumably common to many forms of clerical work. Certain exponents of so-called general clerical examinations recognize that they

[1] A. W. Kornhauser and F. A. Kingsbury, *Psychological Tests in Business,* Chicago, 1924, p. 82.

[2] C. S. Yoakum, and M. A. Bills, "Tests for Office Occupations," *Ann. Amer. Acad. Pol. Soc. Sci.*

[3] R. N. Anderson, "Measurement of Clerical Ability, A Critical Review of Proposed Tests," *Pers. Jour.,* 8 (1929), p. 242.

may be dealing with what is essentially general intelligence, measured by a test phrased in the context of clerical occupations. So, for example, Thurstone has stated his disbelief that "office work has any special abilities that have so far been demonstrated" and has confined himself to the development of an examination with "an appropriate intelligence level and content that appeals to the applicant for an office position. This reduces itself to the same type of problem that is found so frequently in preparing vocational tests; namely, the preparation of an intelligence test out of relevant content." [4]

Toops has shown a leaning toward the same opinion in his statement that "it may well be that general intelligence, which functions so highly in the acquisition of success in grade school work, functions equally well in its acquirement of those things considered essential in a business college. Likewise, a high degree of general intelligence may make possible a short learning period for acquiring proficiency in a business occupation; it may even be a minimum essential for entrance to some of the higher level clerical occupations." [5] Toops further recognizes that the high correlation between his tests of "general clerical ability" and success in business school work in stenography, typing, and bookkeeping may actually be due to its value as a measure of ability to deal with ideas rather than to its value as a test of ability to deal with clerical items and procedures. At the same time, following Thorndike,[6] he still makes use of the concept of general clerical ability, or the ability to deal with clerical items as though it were something distinct from general intelligence.

Other investigators still adhere even more firmly to the concept of clerical aptitude as a unique trait or combination of unique traits which has nothing in common either with mechanical ability or other traits that are most important for success in non-office occupations. This, for example, is very apparent in a recent investigation by Andrews at the University of Minnesota, involving a test (*Minnesota Clerical Checking Test*) which apparently measures aptitude for general clerical work. Low correlation with standard intelligence tests is cited as evidence that "the test is measuring a unique trait in which academic intelligence is conspicuous by its absence." [7]

THE MEASUREMENT OF GENERAL CLERICAL ABILITY

(1) *Link's Battery of Clerical Tests*

Among the earliest tests for general clerical ability is a battery, prepared by Link, divided into two groups, (1) tests for *technique*, in-

[4] L. L. Thurstone, "Standardized Tests for Office Clerks," *J. App. Psych.*, 3 (1919), pp. 248–251.

[5] H. A. Toops, *Tests for Vocational Guidance of Children Thirteen to Sixteen*, New York, 1923, p. 109.

[6] See Chapter VIII, pages 131–32.

[7] Cited from M. Pond, "What is New in Employment Testing?" *Pers. J.*, 11 (1932), pp. 11–12. See also Chapter VIII, pages 132–33.

cluding (a) motor steadiness, (b) simple arithmetical calculations, (c) card-sorting, (d) substitutions; and (2) tests for *intelligence*, including (a) Woodworth-Wells Hard Directions, and (b) Analogies.

After a preliminary try-out the tests were given to 935 clerks. Informal ratings on progress, obtained every month for a period of 3 months on 188 test cases, showed the following percentages rated as "good" at the end of each period:

At the end of one month	75%
At the end of two months	89%
At the end of three months	92%

Although there are technical weaknesses in this validation procedure, which are recognized by the investigator, the study is of interest from the viewpoint of method and of numbers involved. Incidentally, it is interesting to note the conclusion reached by Link that "one of the most valuable features of the systematic follow-up was to reveal discrepancies between particular tests and particular types of work, and thereby point out *the need for a more careful study of the varieties of clerical work and, at the same time, a more careful adaptation of specific tests to meet these varieties.*[8]

(2) *The Thurstone Clerical Test*

Among other early tests for general clerical work is an examination devised by Thurstone,[9] consisting of 8 parts as follows:—

1. *Checking errors in addition and subtraction.*
2. *Underscoring incorrectly spelled words.*
3. *Attention test—cancelling four letters, X, Z, U, C.*
4. *Code-learning test.*
5. *Arranging names alphabetically under designated cities.*
6. *Classification of insurance policies.*
7. *Arithmetic test, including addition, subtraction, multiplication, fractions, and percentage.*
8. *Proverbs test*—requiring the subject to match 10 proverbs with 10 other proverbs so that the two proverbs in each pair will have the same meaning. The examination with items arranged in omnibus form, has a maximum time limit of 90 minutes.

In a preliminary evaluation the test was given to 100 employees of a large insurance company, ranging from minor executives to office clerks doing routine work. The employees were then rated in 5 classes with respect to grade of office work. The grade of work done by these employees correlated as follows with:

[8] H. C. Link, *Employment Psychology*, New York, 1919, p. 86. Italics by the author.
[9] L. L. Thurstone, *op. cit.*

ZERO-ORDER CORRELATIONS		MULTIPLE CORRELATIONS	
Accuracy in test	.50	Accuracy and speed	.61
Speed in test	.42	Schooling and age	.52
Schooling	.47	Accuracy, speed, and schooling	.64
Age	.35	Accuracy, speed, schooling, and age	.67

In a later study[10] a comparison was made between test scores and the efficiency of 500 clerks in a government office. Ratings by supervisors, civil service efficiency ratings, record of education, and a record of salary were combined into a single standard of job accomplishment in making this comparison. Clerks who were above average on this joint criterion were called *good;* those below average, *poor.* According to the investigator, the relationship shown in Table 33, representing the status of 20 reviewing clerks, was found to hold approximately for the entire clerical force.

(3) *General Clerical Tests in the United States Civil Service*

A somewhat different development in the way of a general clerical examination is the test devised under the direction of O'Rourke, for use by the United States Civil Service Commission. One of the first tasks undertaken by the Research Section,[11] following its establishment in 1922, was to revise the general clerical examination then in use.[12] The items included in the final revision covered: *spelling, penmanship, arithmetic, miscellaneous clerical activities, true-false test* or *location of cities, similarities, alphabetical classification, apparatus, analogies, checking,* and numbering items according to a *code classification.*

The validity of the test was investigated by comparing the test scores of 90 clerks with 3 independent ratings on efficiency, on the basis of which the employees were classified on a 1 to 7 scale. No clerk was selected whose 3 efficiency ratings differed more than one point on the scale. The correlation between revised scores and efficiency ratings proved to be .64. Age was found to have no influence on test scores. The correlation between experience and efficiency proved to be 0.22. These results led to the adoption of the test for use in examining applicants for government clerical positions.

It is evident, from the description of the examination, that it includes many items more indicative of educational achievement than of underlying ability. In many respects it resembles a "trade" more than an "ability" test. This is of course recognized by the investigators

[10] "Testing Men Like Material," *Factory,* (1923), pp. 294–5.

[11] For brief history of the development of the Research Division see page 317.

[12] H. A. Filer and L. J. O'Rourke, "Progress in Civil Service Tests," *J. Pers. Res.,* 1 (1923), pp. 484–520.

who, however, stress the fact that this "cross section" of the more typical of clerical duties constitutes a general clerical examination of high predictive value in the selection of employees for this type of work. In fact, it is found to be a "better index of clerical ability" [13] than the combined factors of education and experience.

The original test has undergone revision since 1922. So, for example, on the basis of a study of 1000 papers and of additional examinations administered to the 90 clerks from the Civil Service Commission's office (experimental group) new material was developed which promised forecasting efficiency represented by a coefficient of .70. Moreover, the principle of the general clerical examination has been extended to the development, among others, of a "general test," to be described below, that has been found useful in predicting the efficiency of typists and stenographers.

TESTS FOR SPECIFIC OFFICE OCCUPATIONS

(1) *Typists and Stenographers*

The selection of typists and stenographers involves the use of both "trade" and competency tests.[14] The former are employed to measure proficiency in typing and dictation; the latter to measure general adaptability to the office situation and ability to perform certain specialized tasks. *Inasmuch as industry does not undertake to give training for these types of work, prediction of typing and stenographic "ability" or "aptitude" is not a problem in vocational selection.* For this reason, the author will not consider important investigations by Lahy,[15] Bieneman,[16] Tuttle,[17] Muscio and Sowton,[18] Runge,[19] Rogers,[20] and others, designed primarily to measure ability to profit from training and to become proficient in these activities.

Trade Tests in Typing and Stenography

Trade tests in typing and stenography generally consist of appropriate material to be copied or transcribed from dictation under prescribed conditions. Characteristic of this type of test is the *Army*

[13] *Ibid.*, p. 516.

[14] For a general review of studies and of available tests see M. Freyd, "Selection of Typists and Stenographers: Information on Available Tests," *J. Pers. Res.*, 5 (1927), pp. 490–510.

[15] J. M. Lahy, "Les Conditions psycho-physiologiques de l'Aptitude au Travail dactylographique," *J. Psych. Path. Gen.*, 15 (1913), pp. 824–35.

[16] D. Bieneman, "Ability in Typewriting in Relation to Vocational Guidance," *Int. Lab. Off. Series J.*, No. 2, Geneva, 1923, pp. 46.

[17] W. W. Tuttle, "The Determination of Ability for Learning Typewriting," *J. Educ. Psych.*, 14 (1923), 177–81.

[18] B. Muscio and S. C. M. Sowton, "Vocational Tests and Typewriting," *Brit. J. Psych.*, 13 (1923), 344–69.

[19] W. Runge, "Eignungsprüfung und Wettbewerbleistungen von Schreibmaschinisten," *Ind. Psychot.*, 3 (1926), 129–40.

[20] H. W. Rogers, "Some Empirical Tests in Vocational Selection," *Arch. of Psych.*, No. 47, (1922), pp. 47.

TABLE 33

TEST SCORE	PERCENTAGE WHO ARE GOOD CLERKS
20–39	9
40–59	33
60–79	45
80–99	63
100–119	87
120–139	100

Trade Test for typist,[21] consisting of approximately 300 words with instructions to type as rapidly as possible, with a minimum number of mistakes. The score is obtained by adding the number of errors to the number of minutes required for copying and multiplying by 10. Applicants with scores from 0 to 85 with not more than 5 errors are rated as *Experts;* 0 to 86 inclusive with more than 5 errors, *Journeymen;* 87 to 115 inclusive, *Apprentices;* 150 and above, *Novices.*

The Army test for stenographers [22] is a sheet containing two paragraphs (approximately 400 words) of abstract material, which the subject copies in shorthand and transcribes as quickly as possible. Number of errors added to the time (in minutes) for copying and transcribing, multiplied by 10 constitutes the final score. Standards for grading the applicant in terms of expert, journeyman, apprentice, and novice are provided.

Link [23] has employed a letter consisting of 150 five-space units in selecting typists. In examining stenographers the same letter is dictated to the applicant who transcribes it from shorthand notes. Time and accuracy are combined in scoring.

Tests of proficiency in typing from *plain* copy, from *tabulated* copy, and from *rough draft,* are being employed by the author in selecting typists. In administering the tests the author has followed O'Rourke [24] in requiring applicants to copy as much as they can in a certain time, instead of following the traditional procedure of presenting a certain amount of material and making a record of the time required for copying such material. For measuring proficiency in stenography three letters are dictated at the fastest rate at which the subject can take the letters. Each is graded by subtracting from 200 the number of 15 second periods of transcription, plus twice the number of 15 second periods of dictation, plus the number of errors in punctuation and capitalization, plus twice the number of corrected errors, plus three times the number of other uncorrected errors. Norms for both

[21] J. C. Chapman, *Trade Tests,* New York, 1921, pp. 319–321.
[22] *Ibid.,* pp. 322–324.
[23] H. C. Link, *op. cit.,* pp. 88–102.
[24] L. J. O'Rourke, *Annual Report of Director of Research, U. S. Civil Service Comm.,* Washington, 1930, p. 39.

typing and stenographic tests have been established by examining over 100 typists and stenographers employed by the Philadelphia Electric Company.[25]

Burt[26] has used two shorthand tests, one for measuring speed in taking dictation and the second testing accuracy in taking unfamiliar words. Tests for typists include typing from memory, from copy, from corrected copy, arrangement on page, tabulation, and copy from illegible handwriting. Applied to 30 stenographers employed in a Government office the shorthand tests correlated 0.79 and typing tests 0.60 with activity criteria.

An interesting departure in proficiency tests for stenographers has recently been made by O'Rourke, who has trained examiners to dictate at constant rates of speed so that this part of the test may be given under absolutely standard conditions. Although interesting from a methodological viewpoint, the procedure has little to commend it for ordinary industrial usage, since speed and accuracy in transcription are much more important in determining ultimate proficiency than the rate at which notes are taken. However, it may be possible that a minimum dictation rate is a factor to be considered in the development of such tests.

Competency Tests in Typing and Stenography

Typists and stenographers in most offices are engaged not only in duplicating material and in transcribing notes but are required to perform many other duties. For this reason tests of general adaptability and of competency for specialized tasks must be combined with trade tests in forecasting success or failure of applicants for employment. Link[27] has combined substitution, spelling, context, and grammar tests with measures of proficiency in selecting stenographers. Shellow[28] recommends an intelligence test with subject material germane to problems with which stenographers must deal and reports a correlation of 0.73 between such a test and rankings of 24 stenographers by an examiner who knew their work at first hand and who took into account salary earned, difficulty of work handled, opinions of department heads, etc.

A striking illustration of the use of a test for predicting efficiency in the general activities of the typist and stenographer is found in the recent work of O'Rourke,[29] who has made use of a general test to determine whether typists possess judgment and have a knowledge

[25] A report on these tests is in preparation for publication.

[26] C. Burt, "Tests for Clerical Occupations," *J. Nat. Inst. Ind. Psy.*, 1 (1921), pp. 23–27; 79–81.

[27] H. C. Link, *op. cit.*, pp. 88–102.

[28] S. M. Shellow, "Intelligence Test for Stenographers," *J. Pers. Res.*, 5 (1926), pp. 305–308.

[29] L. J. O'Rourke, *Annual Report of the Director of Research, U. S. Civil Service Comm.*, Washington, 1930, pp. 36–39.

of grammar and spelling. This test is made up of 80 judgment, vocabulary, reading, comprehension, spelling, and grammar items.

In one study this test was given to 51 stenographers and typists employed in a large industrial organization. A comparison of test scores and efficiency ratings revealed a correlation of + 0.71 between the two. Of 25 per cent who made the highest scores approximately 90 per cent were above the average of the group in efficiency. Another study of 80 stenographers and typists employed by one of the largest industries in this country gave a correlation of + 0.76 between the

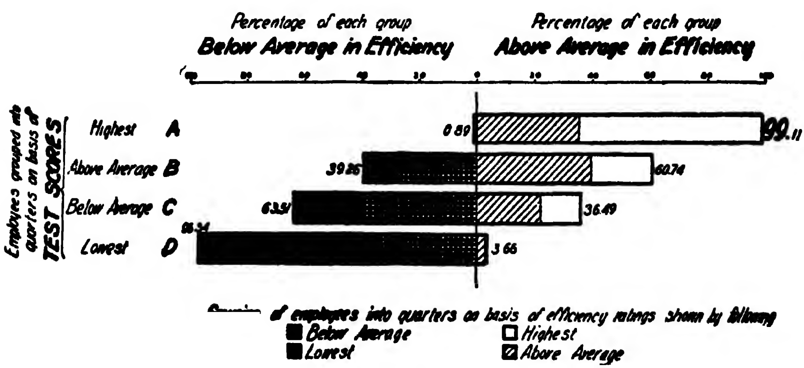


FIGURE 43. *Relation Between Scores on General Test (Represented by Horizontal Bars) and Efficiency Ratings (Represented by Shading). Study of 80 Stenographers and Typists*

(After O'Rourke)

general test scores and efficiency. The relationship between the two is shown in detail in Figure 43.

Results on this test, as is evident, are clearly influenced by educational achievement. However, it may be very well, as O'Rourke has informally suggested, that the examination of this influence is more important in predicting success in many forms of office work than the measurement of underlying abilities of the type tested by the usual "general intelligence test" or "general clerical" examination. On the other hand, a correlation of + 0.72 ± .03 found by the author between the Otis test and an examination such as that employed by O'Rourke (119 subjects) suggests that the latter may actually tap somewhat the same traits as are measured by the ordinary general intelligence test.

(2) *Other Office Occupations*

Comparatively little work has been done in prediction for particular office jobs other than those of typist and stenographer. Preliminary

experiments on comptometer operation are reported by Link [80] who, in one study, gave a series of tests to 3 groups of approximately 140 operators of computing machines, 120 applicants for this work, and 80 pupils entering a class for instruction in the operation of calculating machines. Aside from a proficiency test in machine operation, a mental alertness and a test requiring a substitution of numbers according to a code were found most useful. However, evaluating data is reported only in the case of 12 individuals. It is interesting that no correlation between general intelligence and efficiency was found in this study. Further work on comptometer operation has been done by Bills.[81]

Procedures for employing a standard battery of tests and varied weightings for the selection of auditing clerks, sorting clerks, posting clerks, have been described by the author,[82] but there has been inadequate follow-up on this battery.

Marcus has compared scores on a battery of 9 tests with the performance of 130 Hollerith machine operators. The battery included the following tests: (1) *Cancellation* (cancelling A's); (2) *Opposite* (given a word, to write its opposite); (3) *Whole part* (given an object, to write some part of that object); (4) *Substitution* (100 goemetric forms—random distribution, to write in each form a number according to a code); (5) *Directions* (the task being to obey complicated directions); (6) *Number Checking* (to draw a line through every number containing both 5 and 9; (7) *Completion* (fill in the words of mutilated sentences); (8) *Verb Object* (given a verb to write its object); (9) *Logical sequence* (given a paragraph with sentences disarranged, to put them in proper order).

Test scores were compared with a criterion of efficiency obtained by multiplying speed and accuracy. In computing the criterion—

(1) A daily output of 3200 cards was considered 100 per cent speed.

(2) Total absence of errors was considered 100 per cent accuracy.

(3) Fifty was deducted from the actual output of cards for every error with a proportional drop in the speed rating.

(4) The final per cent rating was obtained by dividing "revised speed rating" by the "actual speed rating."

The following correlations were obtained by grouping tests into batteries. (Table 34.)

In a more recent investigation Monroe and Raphael [83] applied tests of (1) *immediate memory for numbers*, (2) *concentration of attention*,

[80] H. C. Link, *op. cit.*, pp. 88–102.

[81] M. A. Bills, "Methods for the Selection of Comptometer Operators and Stenographers," *J. App. Psych.*, 5 (1921), pp. 275–283.

[82] M. S. Viteles, "Job Specifications and Diagnostic Tests of, Designed for the Auditing Division of a Street Railway Company," *Psych. Clin.*, 14 (1922), pp. 83–105.

[83] M. S. Monroe and W. Raphael, "Selection Tests for Clerical Occupations," *J. Nat'l Inst., Ind. Psych.*, 5 (1930), pp. 134–135.

TABLE 34

	r	P.E.
Team 3 (134 cases) Tests 4—7—9	.453	.045
Team 5 (134 cases) Tests 2—3—4—7—9	.448	.045
Team 6 (138 cases) Tests 1—2—3—4—7—9	.373	.05

(3) *intelligence,* to 15 experienced Hollerith machine punchers. A comparison of test scores with number of cards punched during 6 months previous to date of testing gave a correlation of 0.60 + 0.01. The tests were particularly helpful in picking out 4 of the 5 poorest punchers. Couvé[34] likewise reports satisfactory correlation on a battery of 8 tests with the performance of 31 Hollerith card operators.

(3) *Supervisory Occupations*

Supervisory jobs have been considered in a few studies. In one, a mental alertness test was given to 28 minor executives in a clothing manufacturing establishment. Close agreement is reported between test scores and ratings provided by 6 superior executives.[35] However, this finding is not confirmed in a somewhat more recent study by Bingham and Davis,[36] in which no agreement was found between experience records containing personal information about 73 business executives attending a conference on financial statistics and the results of an intelligence test.

Still more recently Beckman and Levine, of the Cincinnati Civil Service Commission, have employed the *Allport A.S. Reaction Study,* a short form of *Personality Inventory C-2* and a *Directions Test,* in an attempt to predict supervisory ability. The experimental group included 29 city executives (including the city manager, department heads, and bureau chiefs) and a control group of 31 water meter readers. Various efficiency ratings were employed as criteria. On the basis of a correlation of 0.33 between unofficial ratings by the Director of Personnel and scores on the Allport test the conclusion was reached that this test has value in selecting executives. The surmise is also made that "had the Personnel Office been more intimately acquainted with the executives and their abilities, it is possible that a higher correlation would have resulted."[37] On the basis of somewhat similar

[34] R. Couvé, "Über die Untersuchung des Lochkartenpersonals bei der Deutschen Reichsbahn," *Ind. Psychot.*, 4 (1927), pp. 91–93.

[35] W. D. Scott and R. C. Clothier, *Personnel Management*, Chicago, 1923, pp. 643.

[36] W. V. Bingham and W. T. Davis, "Intelligence Test Scores and Business Success," *J. App. Psych.*, 8 (1924), pp. 1–22.

[37] R. O. Beckman and M. Levine, "Selecting Executives," *Pers. J.*, 8 (1930), p. 419.

data the conclusion was reached that the Personality Inventory is better for selecting water meter readers.

It is evident from the results which have been cited in the case of supervisors, as well as on other office occupations, that the record of accomplishment in this field is not a brilliant one.

SELECTION OF EMPLOYEES FOR PUBLIC SERVICE

Recent years have witnessed a growth of interest both in the United States and Europe in the application of psychological tests in the selection of government employees. The importance of this is perhaps evident in the fact that the annual payroll of the United States Executive Civil Service in 1926 amounted to more than $800,000,000.[38] Recognizing the significance of improved methods in selection as a possible means of promoting proficiency, the United States Civil Service Commission took steps as early as 1917 to determine the applicability of psychological methods in devising tests for applicants for Civil Service positions. Thorndike and Scott [39] were consulted on this problem in that year. Yerkes carried out a preliminary experiment involving the application of the Army Alpha to 100 clerical employees shortly after the War. In April, 1919, another preliminary experiment was carried out in the Baltimore Post Office under the direction of Watson. Following a survey of the Commission's examination methods by Ruml in 1920, there was established, in 1922, a Research Section of the United States Civil Service Commission which since the date of its inception has been under the direction of L. J. O'Rourke.

Selection of Mail Distributors

In considering clerical tests some reference has been made to the work of this section. A brief discussion of an investigation in the selection of *mail distributors* for the Postal service will serve further to illustrate the achievement of psychological tests in improving selection in the Civil Service. In normal times approximately 15,000 to 20,000 distributors are hired each year. These, together with the railway mail clerks, represent the greater part of the 310,000 postal employees.[40] The mail distributors must memorize from 2000 to 5000 city names and keep constantly in mind changes in the distribution schedule.[41] Working at a normal rate the average number of letters distributed by this worker is approximately 1300 per hour.

A preliminary job analysis in 1922 led to the development of 3 tests for a try-out in the selection of mail distributors. (1) In the

[38] L. J. O'Rourke, "Saving Dollars and Energy by Personnel Research," *J. Pers. Res.*, 4 (1926), p. 351.

[39] H. A. Filer and L. J. O'Rourke, *op. cit.*, pp. 484–489.

[40] L. J. O'Rourke, *A New Emphasis in Federal Personnel Research and Administration*, Washington, 1930, p. 17.

[41] L. J. O'Rourke, *Saving Dollars and Energy by Personnel Research*, *op. cit.*, p. 450.

first, a *sorting test,* squares representing boxes are placed at the top of a page. Each square is numbered and in each are printed the names of 3 or more cities, indicating that mail in these cities is to be placed in that box. Below the boxes is printed a list consisting of repetitions of names appearing in the scheme. On a line following each name the candidate places the number of the box into which a piece of mail so addressed would be thrown.

(2) *Memory Test.* The subject memorizes a distribution scheme

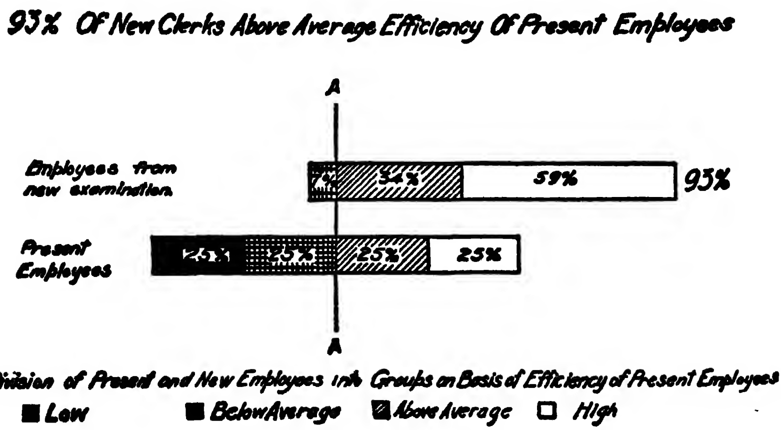


FIGURE 44. *Improved Selection of Mail Distributors—U. S. Postal Service* (*After O'Rourke*)

and is then required to write from memory the correct number of each of the cities listed on a page.

(3) *Following Instructions Test.* In this the subject follows a complicated series of instructions connected with the distribution of mail.

After preliminary trials the tests were given to 124 employees of the mail department in the Chicago Post Office. Test results were compared with the criterion described elsewhere, and a correlation of + 0.71 obtained between the criterion and the 3 tests combined by multiple correlation method. After this, the extent to which each test measures independent factors was verified by an examination of the scores of 600 competitors. An examination of employees in post offices and those of competitors showed that the range of scores on the tests, as well as the average, are comparable for the two groups and that, from the viewpoint of test scores, the highest 25 per cent of the competitors will be equal to the highest 25 per cent of present employees. From a study based on a representative group of present employees it was found that of those making the highest 25 per cent of the test scores 93.1 per cent were, in efficiency, above the average

of the entire group tested (Figure 44). On this basis the conclusion was drawn that it may be expected that 93 per cent of appointees selected through these tests will be more efficient than the average of present employees.[42]

The economy through the use of such tests in civil service examinations comes not only through increased efficiency, but in an actual reduction in the cost of giving the new-type examination to prospective applicants. The new clerk carrier examination prepared by the Research Section can be scored and handled in 40 to 50 per cent less time than the examination which it replaced. In an examination in which 60,000 to 80,000 are competing this makes possible a saving of time equivalent to that for scoring from 24,000 to 40,000 competitors' papers.[43] Possibilities of economy in this direction are evident when it is known that in the year 1924 alone, 25,000 competitors were examined for railway postal clerk positions and 60,000 as post office clerks and letter carriers.[44]

Selection of Policemen

The selection of policemen and detectives represents another illustration of the extent of psychological testing in government service.[45] In Berlin,[46] in an examination lasting about four hours, applicants for police service, after filling in a personal data sheet, are required to take two series of tests. The first includes a number of tests of the pencil and paper type, given to 40 or 50 applicants at one time which make possible a preliminary classification on the basis of intellectual capacity. The second series includes a variety of individual performance tests, designed to measure such traits as reaction to fear, complexity of motor response, suggestibility, etc., of importance in general police service, and those which are of particular significance in the more specialized services of traffic officer, river police service, police patrol operation. A description of a few of these tests will serve to make clear the methods which are employed in the quest for efficient police officers.

The ability to reproduce visual images involving spatial relations, considered by Schulte to be of extreme importance in police work, is measured by a test in which the following instructions are given:

It is reported that suspicious noises are coming from a house, the residents of which are away. The lay-out of the house is as follows. It is a long, narrow dwelling, the length stretching from north to south. On the northern narrow side of the house a tradesmen's door leads directly into the kitchen, which stretches across the entire width of the house. Ex-

[42] *Ibid.*, p. 450.
[43] *Ibid.*, p. 448.
[44] *Ibid.*, p. 453.
[45] M. S. Viteles, "Psychological Methods in the Selection of Policemen in Europe," *Ann. Amer. Acad. Pol. Soc. Sci.*, 146 (1929), pp. 60–65.
[46] R. W. Schulte, *Psychotechnik und Polizei*, Oldenbourg, 1926, pp. 214.

tending from the center of the kitchen wall is a long, narrow corridor leading to a reception room. On each side of the corridor are a small room and a large room, lying in the order given with respect to the kitchen. The main entrance to the house is by steps leading into the west side of the reception room. Leading from the south side of the reception room (on the west side of the house) is the music room; on the east side is the dining room. There is a glass door between the dining and the music rooms. On the south side of the dining room is an outside balcony.

This description is read once and the applicant is then required to draw a ground plan of the house. The sketch is scored for errors.

As a measure of his memory for places the applicant is handed a copy of the diagram shown in Figure 45, and required, after viewing it for about three minutes, to reproduce it. The reproduction is scored for errors, and omissions.

Resourcefulness, ingenuity in difficult situations, and allied traits are, according to those who designed the tests, measured by putting to the applicant such questions as the following:

In the course of a visit made with the purpose of arresting one of a band of criminals, you are knocked down and dragged into a cellar, where two thugs with drawn revolvers stand guard over you. You overhear them saying that the leader of the band is planning to cross the border after a big haul, and that he is to be followed, within a few hours, by those who are guarding you. The guards are quite talkative, and willing to chat with you, but, at the same time, are very watchful. It is impossible to consider getting them drunk. What would you do to outwit them?

Other tests of the same type are provided for the measurement of temperamental traits such as sense of humor, reaction to fear, courage, and so forth. Quantitative scoring methods are provided in the case of practically all of the tests. In addition, emphasis is placed upon the importance of qualitative observations made in the course of the examination. So, for example, in Berlin, a definite observation rating is assigned at the close of the testing period and this rating is employed, as well as the objective test scores, in determining suitability for employment.

Schulte reports a correlation of + 0.81 between test scores and efficiency ratings of 21 policemen, and a correlation of + 0.89 between efficiency ratings and the rankings of candidates on the basis of the observation of performance during the tests.

Performance tests have also been employed in batteries for the selection of policemen devised by Moll and Piorkowski,[47] Roemer,[48]

[47] A. Moll and C. Piorkowski, "Psychotechnische Prüfung von Kriminalbeamten," *Z. ang. Psy.*, 18 (1921), 107–10.

[48] L. S. A. M. v. Roemer, "Prüfung von Kriminalanwärten," *Z. ang. Psy.*, 18 (1921), 107–10.

Schneickert,[49] and Graf.[50] Among recent American investigations in this field is a battery employed by O'Rourke.[51] Tests of ability to

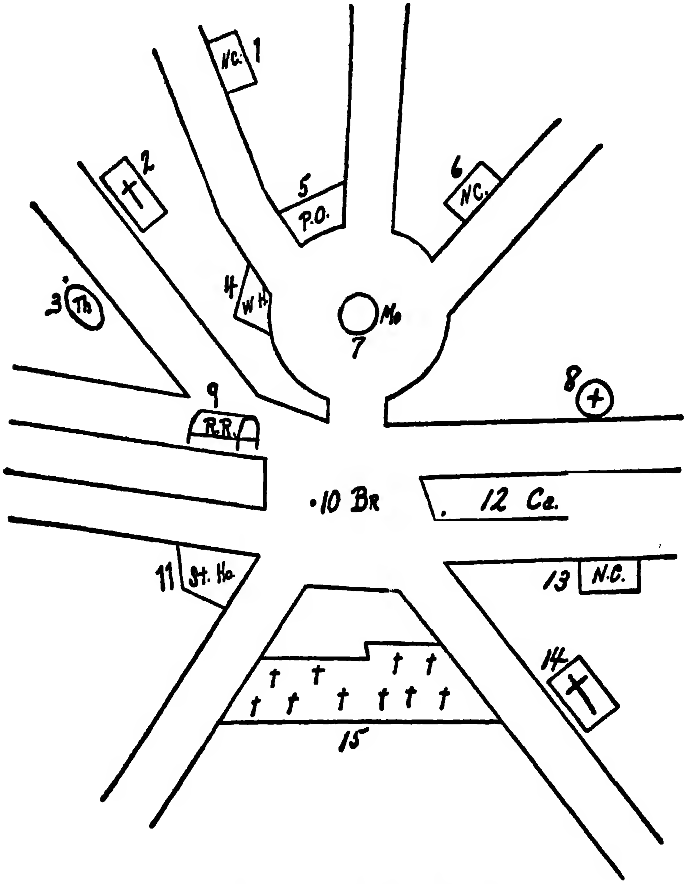


FIGURE 45. *Diagram Used in Testing Memory for Places*

1. *Night Club*	6. *Night Club*	11. *Storage House*
2. *Church*	7. *Monument*	12. *Canal*
3. *Theatre*	8. *Military Hospital*	13. *Night Club*
4. *Watch House*	9. *R. R. Station*	14. *Church*
5. *Post Office*	10. *Bridge*	15. *Garden*

(*After Schulte*)

[49] H. Schneickert, "Die psychotechnische Methode bei der Answahl der Tuchtigsten, inbesondere im Kriminaldienste," *D. St. Z.*, 7 (1920), 221–25.

[50] O. Graf, "Das Ausleseverfähren bei der bayerischen Schutzpolizei," *Psychot. Z.*, 4 (1929), pp. 109–113.

[51] L. J. O'Rourke, "The Use of Scientific Tests in the Selection and Promotion of Policemen," *Annals, Amer. Acad. Pol. Soc. Sci.*, 146 (1929), pp. 147–159.

reason, to interpret situations (from the observation of a picture), judgment tests of general adaptability (intelligence), are included in the series. By using a battery consisting of a general adaptability test and 4 of the special tests a coefficient of correlation of 0.66 was obtained between test scores and ratings on general efficiency in police work.

SUMMARY, CHAPTERS XIII TO XV INCLUSIVE

In these chapters have been presented the methods and results of typical investigations in the use of selection tests in a variety of fields. A number of occupations such as those of salesman,[52] telegrapher, telephone operator, on which research work has been done have not been considered. However, in spite of these omissions, the chapters give a fairly comprehensive picture of actual accomplishments in the use of scientific selection tests.

[52] In the case of salesman attention has been drawn in Chapter X to the use of application blank data which, on the whole, has proven to be a more satisfactory method for predicting success in this work than have psychological tests.

SECTION THREE

MAINTAINING FITNESS AT WORK

XVI. SAFETY AT WORK

According to a recent report of the National Safety Council,[1] approximately 99,000 people were killed by accidents in the United States during 1930. This number represents a death rate from accident of 80.4 per 100,000 population. In 1929 the *accident* was *second* in rank of the leading causes of death in the case of men and *eighth* in the case of women.

Approximately twenty per cent (19,000) of all fatal accidents in 1930 were sustained in the industrial situation. It is significant to note that 3,000, or approximately 17 per cent of these, involved the operation of a motor vehicle. For industry as a whole there are in addition approximately 130 non-fatal lost time injuries to each fatal injury. This indicates that there were approximately 2,500,000 non-fatal industrial lost time accidents during 1930.

Because of widely different practices followed by the various States in accumulating and reporting accident data, it is impossible to obtain an exact figure on the number and cost of industrial accidents. Moreover, there is no uniform agreement in estimates of number or cost. Dublin,[2] for example, gives 24,000 as the number of deaths resulting annually from accidents in industry. In addition he estimates that there are at least 3,000,000 accidents per year serious enough to cause loss of time from work among 45,000,000 occupied persons in the United States. If the loss of future working life is computed for fatal and permanent diability accidents and added to the actual days lost by reason of temporary disability, the enormous total of 300,000,000 days of labor can be estimated as the annual loss in this country,—the equivalent of 1,000,000 men working a full year. Applying a ratio suggested by Stewart,[3] in an earlier statement on loss resulting from accidents, the annual wage loss to those involved is approximately $1,-300,000,000.

The problem of arriving at the total cost of industrial accidents is further complicated by the existence of numerous costs other than such *direct* costs as payment for medical treatment and insurance.[4] To these must be added the expense of selecting and training new men

to take the place of those who are injured, and the cost of maintaining safety and welfare departments which function in preventing accidents and in caring for injured employees and their families. In addition, there is a slowing up of work, and possibly a stoppage of work, which add to production costs. Combined with these is the financial burden upon public agencies in supplementing the budgets of families whose income has been reduced by an accident to the wage-earner. The total of such charges, as suggested by Heinrich,[5] may very well bring the approximate annual economic loss from industrial accidents well above $5,000,000,000.

THE SOCIAL EFFECTS OF ACCIDENTS

The cost of accident cannot be expressed in money alone. The adverse effect upon the individual and upon the family is beyond evaluation. The social effects of accidents are well illustrated in a study of child labor in a coal mining community which showed that over half the children between 13 and 16 years of age in this community had left school to seek employment.[6] "Family need was the reason most frequently given for leaving school and going to work, and the proportion of children who had left school for work was greater as the father's income was less. The number of child wage-earners decreased as the father's earnings increased. Over one-half of all the fathers or heads of households earned less than $1,250 a year. Nearly three-fourths of the fathers who reported had periods of unemployment during the year. Besides unemployment, *accidents were an important factor in family distress, almost one-fifth of all the fathers working in the mines having met with accidents at their work within the three and one-half years preceding the inquiry.*" [7]

For a family at the borderline economic level an accident may mean a descent from independence to economic dependence. The need of accepting financial aid from a charitable agency may affect all the social relationships of the family. The ramifications in the way of modifications in social standards, of conflicts arising from this situation or from the attempt to meet the situation unaided, are beyond description. In addition, the individual may undergo a personality change as a result of an accident. Stephenson points out, for example, that as a result of an accident "certain types may be apprehensive of further accident; others may experience a dull resentment; while others may actively engage in revengeful efforts. Whatever the reaction may be, the mental attitude of the victim to his environment is altered, and the change is not for the better—, in the immediate future

[5] H. W. Heinrich, "Cost of Industrial Accidents to the State, the Employer, and the Man," *Mo. Labor Rev.*, Nov., 1930, pp. 72–80.

[6] *Eighth Annual Report*, U. S. Children's Bureau, 1920, p. 22 (Quoted from G. S. Watkins, *op. cit.*, p. 274).

[7] Italics by the author.

at any rate,—though ultimately the result may be all to the good . . . on the principle that the burnt child dreads the fire."[8]

MOTIVES IN ACCIDENT REDUCTION

The direct and indirect costs of industrial accidents and their social effects pointed to the importance of concerted effort to prevent the occurrence of accidents in industry. The impetus to such work came mainly from two directions: 1) from the recognition of social responsibility for the welfare of those injured in industry, expressed in the passage of accident compensation laws, and 2) from the selfish urge of industrial executives to keep at the lowest possible figure the costs imposed by such social legislation. Interwoven with the latter, as well as with the first force, are other factors such as growing interest in the elimination of all forms of inefficiency or waste[9] in industry, the development of a humanitarian attitude which has crept into American industrial life, etc.

ACCIDENT COMPENSATION LAWS

The principles and practices of accident compensation need not be discussed at length here. Compensation laws are generally based on the principle that "since disabling injuries by accident and disease are inevitable concomitants of that mechanical industry which has made modern civilization possible, and the products of which are enjoyed in fullest measure by the classes least exposed to its hazards; since the victims of these injuries are precisely those least able to bear the burden of economic loss themselves or to shift it to others; . . . those who are crippled in the production of the community's wealth, and the dependents of those who are killed, have a right to indemnity from the public for whom they wrought. This principle has been indorsed both by organized labor and by organized capital . . . and forms the basis of legislation in most civilized countries."[10]

Although the United States lagged behind European countries in providing compensation for workers involved in industrial accidents, the development of legislation in this field has been rapid.[11] Definite legal provision for injured workers was first made in Germany, where compulsory insurance against accidents became effective in 1885. Similar laws were adopted by Austria in 1887, by Norway in 1894, and by Great Britain in 1897. In the United States the first accident compensation laws were passed in Maryland in 1902, in Montana in 1910, and in New York in 1911. These first laws were held to be un-

constitutional, but with the passage of compensation laws in California, New York, Washington, and Wisconsin, in 1914, the movement for granting such protection to the worker became effective and rapidly spread until now such laws, in one form or another, are in force in practically every state in the Union.

These laws [12] in general deprive the employer of such defenses as "contributory negligence," "assumption of risks," and "fellow servant," and force him to pay the worker's medical fees and a proportion of wages for the time lost from work. Such legislation imposes the cost of accidents upon industry as a cost of production. In making accidents expensive to industry it has created a selfish urge for the reduction of accidents. "It is through the payment of compensation that the cost of work injuries is brought home to the employer. A high accident rate means a high insurance rate. Accident prevention therefore becomes a business proposition. One of the principal objects of compensation legislation is to stimulate interest in the prevention of accidents, and such laws have given everywhere a notable impetus to the safety movement. The higher the benefits, the greater, of course, will be the incentive to preventive efforts. Full indemnity for deaths and permanent disabilities is particularly important in this respect. In this way, to ordinary humanitarian motives are added the realization that the prevention of accidents is the only effective method of reducing the burden which the compensation system imposes." [13]

THE DEVELOPMENT OF THE SAFETY MOVEMENT IN THE UNITED STATES

The interest in accident reduction in the United States found its first expression in a *safety movement,* promoted in large part by a national organization, the *National Safety Council,* which first assumed importance about 1907,[14] when the iron and steel industry began to give considerable attention to its industrial casualties. Coincident with the organization of the Association of Iron and Steel Electrical Engineers a Safety Committee was established for the purpose of studying accidents occurring in the steel and iron industry.[15] The pioneer efforts of this committee were met with such a wholehearted reception in the industry that the officers of the Association were encouraged to take steps toward establishing a separate safety organization, national in scope, as a co-ordinating agency and clearing house for all phases of accident prevention. A conference, held for

[12] W. H. Cameron, "Organizing for Safety Nationally," *Ann. Am. Acad. Pol. Soc. Sci.,* 123 (1926), p. 27.

[13] J. H. S. Bossard, *op. cit.,* p. 420.

[14] M. W. Alexander, "Need of Safety from the Employer's Viewpoint," *Ann. Am. Acad. Pol. Soc. Sci.,* 123 (1926), p. 7.

[15] L. W. Palmer, "History of the Safety Movement," *Ann. Am. Acad. Pol. Soc. Sci.,* 123 (1926), p. 10.

this purpose in 1912, led to the organization of the *National Safety Council.* From an organization of sixteen charter members this has grown to a membership of more than four thousand,[16] including the majority of the large industrial organizations of the United States. Safety movements in particular industries, such as the railways, the merchant marine, the organization by President Hoover, in 1924, of

TABLE 35

Comparative Results of Accident Prevention Efforts in a Group of Selected Industries in Specified Years [17]

INDUSTRY	NUMBER OF FULL-YEAR WORKERS	NUMBER OF ACCIDENTS	ACCIDENT FREQUENCY RATES (PER 1,000,000 HOURS' EXPOSURE)		ACCIDENT SEVERITY RATES (PER 1,000 HOURS' EXPOSURE	
			RATE	PERCENTAGE OF DECREASE	RATE	PERCENTAGE OF DECREASE
Iron and steel:						
1910	202,157	45,283	74.67	.....	5.20	
1927	395,707	23,338	19.67	73.67	2.30	55.77
Portland Cement Association						
1919	16,247	2,119	43.47	.....	.69	
1927	31,290	1,340	14.27	67.17	.35	49.28
Paper Mills [18]						
1920	26,525	3,684	46.38	.....	2.60	
1927	61,790	5,084	27.42	40.83	1.57	39.62
Chemicals [18]						
1923	6,015	443	24.55	.....	4.78	
1297	84,682	4,364	17.80	27.49	1.90	60.25
Power presses [18]						
1926	126,387	9,184	24.23	.....	1.39	
1927	149,359	8,717	19.45	19.73	.93	33.09

From F. E. Baridon, and E. H. Loomis, *Personnel Problems,* New York, 1931, p. 252.

a *National Conference on Street and Highway Safety,* programs for safety instruction in the public schools, represent further steps in the same direction. However, no other organization has contributed as much as the National Safety Council to the effectiveness of organized safety—to the reduction of industrial and other accidents in the United States.

[16] *Ibid.,* p. 12.

[17] U. S. Bureau of Labor Statistics, *Statistics of Industrial Accidents in the United States to the End of 1927,* Bulletin 490, p. 5.

[18] Industrial Accident experience of members of the National Safety Council.

The effectiveness of the safety movement is reflected in a few figures chosen at random from a recent investigation of the American Engineering Council.[19] The United States Steel Corporation in thirteen years has decreased its accidents 86 per cent. The Clark Thread Company has a record of nearly 10,000,000 man-hours without an accident. One of the plants of the duPont Company with 65 employees has a record of eleven years with only one accident, and that a relatively minor one.

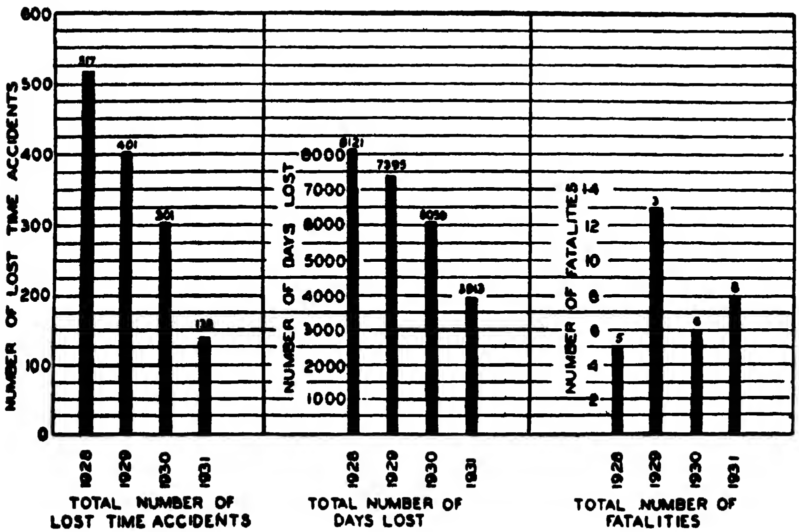


FIGURE 46. *Employee Accident Statistics*

Philadelphia Electric Company

Average Number of Employees

1928—8817
1929—7896
1930—8133
1931—7944

The general trend of results obtained by safety engineers working in industry and applying the specialized techniques developed in connection with the safety movement is shown in Table 35. It also appears in the record for 4 years of a single firm shown in Figure 46. During the years 1928–30, 1562 firms reporting consistently to the National Safety Council showed a 28 per cent decline in frequency rate and a 3 per cent drop in severity rate. Improvement in these selected con-

[19] *Safety and Production*, New York, 1928, p. 6.

cerns is greater than in the country as a whole, but they illustrate the results of accident prevention efforts.

METHODS EMPLOYED IN THE SAFETY MOVEMENT

Industrial accidents may be divided into two general classes: [20]

(1) *Machinery Accidents,* or those resulting from inadequate safeguards of machines in industry.

(2) *Non-Machinery Accidents,* or those resulting from causes other than insufficient machine protection. Such accidents result either from a *personal* predisposition, i. e., as a result of age, inexperience, "carelessness," or from the *effect of machine or plant conditions,* such as ventilation, illumination, etc., *upon the individual.*

In its earliest stage the safety movement was largely concerned with the first type of accidents. Attention was centered upon providing guards for machines and upon guarding belts and gearing which constituted an obvious hazard to human life. Later this was supplemented by an interest in engineering improvements in machines and in the lay-out of the plant which could help reduce accidents attributable to these objective factors. Guarding against machine and plant hazards still continues to be one of the chief interests of the safety engineer in industry.

The concern for the mechanical aspects of safety has been supplemented by an attempt to reduce *non-machinery* accidents through a consideration of *personal factors* in accidents. This naturally followed from the observation that accidents continued to occur even after the installation of guards—oftimes on machines which were considered to be completely guarded or "fool proof." The predominance of personal factors is indicated, for example, in the estimate that "at the present time about one-third of industrial accidents are attributable to machinery, and not more than one-third of these accidents are due to the absence of guards. This leaves about 90 per cent of present-day accidents to be accounted for as failures on part of the human subject." [21]

In so far as the human element is concerned, the organized safety movement in the United States has resorted to: (1) Broadside appeals to worker and to others for co-operation in accident reduction. (2) General education on the value and methods of "safety work."

The devices most frequently employed in appeal and education have included safety posters, safety campaigns, safety contests, and other techniques of mass propoganda. The National Safety Council has taken the lead in the development of programs employing these methods. The safety posters issued at regular intervals by this organization, the guidance given by representatives of the national body to local councils, the pamphlets issued on such specialized problems as

[20] G. S. Watkins, *op. cit.*, p. 326.
[21] A. Stephenson, *op. cit.*, p. 194.

resuscitation, the use of safety devices, the general instruction of the public and of school children, etc., have exercised a tremendous influence on the development of the safety movement.

Until very recently the underlying philosophy of this movement has been that, in so far as the individual is concerned, *carelessness* is the chief cause of accidents. The purpose of mass appeal is to create in the group a more watchful regard for objective conditions which produce accidents. The importance which leaders of the safety movement attribute to carelessness is well illustrated in a description of the safety activities of the American Car and Foundry Company.[22] "Apart from the appliances and devices for guarding and insulating dangerous places and machinery, which the company has installed at great expense, it set itself the duty of enlisting the services of its entire force in a co-operative movement which has accident prevention as its high purpose and goal. This movement is of the utmost importance to the realization of the efficient working of any system of accident prevention. For without the co-operation of the workers, accidents will happen, be the mechanical appliances ever so perfect. Now to bring this about means that the *workingmen must be educated and trained in habits of thoughtfulness and carefulness*. This is not always easy to do; but the intelligence and loyalty of the American worker may be relied on. Once wisely elicited and conserved, these spiritual qualities may be a material asset of incalculable value." [23]

LIMITATIONS OF THE SAFETY MOVEMENT

In recent years the inadequacy of this viewpoint has become increasingly apparent. "Carelessness" is entirely too plausible an explanation of accidents. It is merely a "smoke screen" which interferes with the more detailed examination of physical and, more particularly, mental factors which play a part in accidents. There has been a growing demand, coming largely from outside the organized safety movement, for a more scientific analysis of these factors.[24] As in earlier days the restricted emphasis upon machine guarding resulted from an inadequate conception of engineering possibilities, so it is realized to-day that propaganda and mass education in safety work rest upon an inadequate conception of the complicated personality of those who become involved in industrial accidents. Fisher, for example, points out that "in the safety movement industry has already reached the point of diminishing returns from further efforts with broadside remedies and shotgun prescriptions. In a single decade it has reduced the severity and frequency of accidents in a marvelous

[22] G. A. Orth, "Does Accident Prevention Pay," *Ann. Am. Acad. Pol. Soc. Sci.*, 123 (1926), p. 22.

[23] Italics by the author.

[24] J. H. S. Bossard, *op. cit.*, p. 439.

fashion. It has written into law and into standard practice a routine of mechanical safeguards and safety instruction and inspection which reaches practically every factory in the country. The chief concern of safety engineers, now, is . . . to hold the gains made, to sustain the enthusiasm and interest already aroused, and to keep safety committees going. The fight, the anxiety and excitement of pioneering, have gone out of the job; the safety movement has entered the phase of gleaning. Refinements of old equipment; revisions of, and more "active" photography in old bulletins; new stunts to keep committees awake; new accident tables to keep managements interested—these are the subjects which occupy the engineer." [25]

The chapters which follow will be devoted to a consideration of procedures employed and of results obtained in supplementing the traditional techniques of the safety engineer by a scientific analysis of human personality as an aid in accident prevention.

[25] B. Fisher, *Mental Causes of Accidents*, New York, 1922, pp. 257–258.

XVII. PSYCHOLOGICAL TECHNIQUES IN ACCIDENT PREVENTION

1. INDIVIDUAL DIFFERENCES IN SUSCEPTIBILITY TO ACCIDENT

The first step in the scientific study of mental causes of accidents has taken the form of an analysis of differences in *susceptibility to accident*. The practices of the safety engineer reveal a neglect of individual differences as a possible factor in the accident situation. In so far as the individual involved in an accident is concerned, the injury or fatality has been looked upon largely as a matter of *chance* or as a result of the traditional "carelessness" of the worker. This is evident in the literature of the safety movement, in which there is no end of accident classifications by parts of the body involved, by type of machine, by condition of the plant, but practically no reference to the distinctive features of individual physiological and psychological make-up.

Among safety engineers there has been a casual observation of the fact that some individuals are more frequently involved in accidents than others. In the transportation industry, for example, the existence of "repeaters" has been continually observed, but the significance of this fact, in general, has been almost entirely overlooked. The safety engineer seems to have remained almost untouched by the increasing knowledge of the part played by individual differences as a factor in safety at work. It has remained for the psychologist to introduce the concept and the techniques for measuring individual differences into the study of accidents. It has been his task to demonstrate that individuals differ with respect to susceptibility to accidents as they differ in other traits. Psychological analysis of accidents has shown that accidents *"do not distribute themselves by chance, but that they happen frequently to some men and infrequently to others as a logical result of a combination of circumstances."* [1] Some individuals become more frequently involved in accidents than others because of either an inherent psycho-physiological predisposition toward accidents, or

[1] *The Accident-Prone Employee, A Study of Electric Railway Operation Undertaken by The Cleveland Railway Co., and The Metropolitan life Insurance Co.*, New York, 1930, p. 5.

because of a temporary change in attitude or outlook which increases the probabilities of being involved in an accident when a situation which may lead to one arises. Such susceptibility is referred to as *accident-proneness.*

The existence of *accident-proneness* has been demonstrated in a number of statistical studies of the incidence of accidents among workers. Among the earliest of these is a study by Greenwood and Woods made under the auspices of the Industrial Fatigue Research Board.[2] Starting with the observation that among workers employed for a given period there are some who experienced no accidents, others who experienced a single accident, and still others who were involved in many or *multiple* accidents, the authors investigated three hypotheses with respect to the distribution of accidents.

1. The first is that individual make-up plays no part in the incidence of accidents among members of a group. In this hypothesis participation by the individual in an accident is looked upon as a matter of *chance,* in the same sense that it is chance which leads one to draw an ace of spades from a well shuffled pack. Distribution of accidents among members of a group by chance in this way may be described as a *Simple Chance Distribution.*

2. The second hypothesis is that in a group, the members of which are at first all equally liable to accidents and exposed to the same risks, those who experience accidents are thereby rendered more susceptible to future accidents. The situation here would be similar to that which occurs in connection with diseases, such as tuberculosis, in which a first occurrence of the disease predisposes the individual to a second occurrence of the same illness. The effect of such a factor would produce a distribution of accidents among a group that may be called a *Biassed Distribution.*

3. The third hypothesis is that workers in an individual plant do not start on an equal basis, but that some are inherently more liable to accidents than others. These workers constitute a class markedly susceptible to accidents. The existence of *accident-prone* individuals in a group of workers would cause accidents to distribute themselves in a somewhat different manner than under the conditions described in 1 and 2 above, and give a distribution that may be designated as a *Distribution of Unequal Liabilities.*

Greenwood and Woods have taken accidents occurring in industrial plants and have compared the number of workers with *0, 1,* and *more* accidents with the number that could be expected under each of the conditions described by the three hypotheses outlined above. Statistical formulae suitable for predicting the number of occurrences of *0, 1,* and *more* accidents in the case of a *Simple Chance Distribution, Bi-*

[2] M. Greenwood and H. M. Woods, "The Incidence of Industrial Accidents, with Special Reference to Multiple Accidents," *Ind. Fat. Res. Brd. Rep.,* No. 4, 1919, pp. 28.

assed Distribution and *Distribution of Unequal Liability* have been developed by the authors.[8]

Table 36 shows a comparison of the number of zero, single, and multiple accidents in different plants with the probable number for each of the three hypotheses. In each plant the exposures to risk were

[8] METHODS OF CALCULATING DISTRIBUTIONS

The three distributions shown in the various tables were calculated by the following methods:

1.—*Simple Chance Distribution* (C.D.)

If N be the number of persons and n the number of accidents, the distribution has been taken to be

$$N\left(\frac{N-1}{N}+\frac{1}{N}\right)^{n} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

The terms of which are closely represented by the exponential expression:

$$Ne^{-\frac{n}{N}}\left(1+\frac{n}{N}+\frac{\left(\frac{n}{N}\right)^{2}}{1.2}+\frac{\left(\frac{n}{N}\right)^{3}}{1.2.3}\ldots\right) \quad \ldots \quad \ldots \quad (2)$$

when $\frac{1}{N}$ is small but $\frac{n}{N}$ finite.

The values of (2) are obtained from *Tables for Statisticians and Biometricians,* Cambridge, 1914, pp. 113–121.

2.—*Biassed Distribution* (B.D.)

If it be assumed that the liability to accident is altered by having sustained an accident, a form of distribution which can be used is to compute the numbers having 1, 2, . . . accidents from

$$\frac{N}{s}\left(\frac{N-s}{N}+\frac{s}{N}\right)^{n} \quad \ldots \quad \ldots \quad (3)$$

omitting the first term.

The constant s is derived from the second moment of the statistics by the equation:

$$\mu_2=\frac{n\left\{N-n+s\,(n-1)\right\}}{N^2} \quad \ldots \quad \ldots \quad (4)$$

When greater than unity it denotes an increased liability after the first accident.

3.—*Distribution of Unequal Liabilities* (U.D.)

Supposing the distribution of susceptibility to accidents to be continuous and of the form:

$$y=y^{0}e^{-c\lambda}.\lambda^{r-1} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

where λ is the measure of liability or susceptibility c, r, and yo constants;

Then the frequencies of 0, 1, 2, &c. accidents are given by the successive terms of:

$$N\left(\frac{c}{c+1}\right)^{r}\left\{1+\frac{r}{c+1}+\frac{r\,(r+1)}{2!\,(c+1)^2}+\frac{r\,(r+1)(r+2)}{3!\quad(c+1)^3}+\ldots\ldots\right\} \quad (6)$$

and r and c are obtained from the statistics from:

$$M=\frac{r}{c} \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

$$\mu_2=\frac{r\,(c+1)}{c^2} \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

Where M is the mean and μ_2 the second moment about the mean of the distribution observed.

Cautions respecting the applicability and interpretation of the formulæ chosen are included in the report by Greenwood and Woods cited above.

approximately constant for every member of the group. A variety of plants and a variety of work were observed by the authors in order to test the suitability of each hypothesis under a wide variety of conditions. Table 36 (Shop A) shows, for example, the number of zero, single, and multiple accidents in the case of 648 women workers in a plant manufacturing 6″ H. E. shells. Of these, 447 women were involved in 0 accidents. If the *Simple Chance Distribution* hypothesis of accident incidence is correct 406 women could have been expected to be in-

TABLE 36

Women working on 6-in. H. E. Shell under same conditions in Shops A & B (Period February 13th, 1918–March 20th, 1918)

ACCIDENTS	NUMBER HAVING ACCIDENTS	C.D.	B.D.	U.D.
Shop A				
0	447	406	452	442
1	132	189	117	140
2	42	45	56	45
3	21	7	18	14
4	3	1	4	5
5	2	.1	1	2
TOTAL	648	648.1	648	648
			(P = .13)	(P = .39)
Shop B				
0	397	397	403	398
1	133	163	125	136
2	47	36	44	38
3	5	5	10	10
4	1	1	2	2
5	—	.1	.3	.6
6	—	—	—	—
7	1	—	—	—
TOTAL	584	584.1	584.3	584.6
			(P = .30)	(P = .16)

The meaning of the quantity P given in this and other tables is this: When a hypothesis requires the numbers of observations falling within a series of classes to be a_1, a_2, a_3, etc., and one actually finds b_1, b_2, b_3, etc. observations in these classes, the probability of the discrepancies having arisen by "chance" depends upon the value of the sum of such quantities as:—$\frac{(b_1 - a_1)^2}{a_1}$, and is denoted by the letter P.

For instance, in Table A, Shop A, P = .13 for the B.D. distribution means that were the hypothesis valid, then in every 100 trials we should get no better agreement than actually observed here 13 times. But for the U.D. hypothesis, the chance is better, viz., 39 in 100.

(After Greenwood and Woods)

volved in *0* accidents. If the *Biassed Distribution* hypothesis is correct the number of women involved in *0* accidents should have been 452. If the hypothesis of *Distribution of Unequal Liabilities* is correct 442 of the employees should have been involved in *0* accidents.

A comparison of the actual number of accidents with the probable number under each of the hypotheses shows that the second and third hypotheses fit the actual occurrence of zero, single, and multiple accidents much better than does the hypothesis of *Simple Chance Distribution.*

An example from another plant, Shop B, also indicates the inadequacy of the first hypothesis and the generally more satisfactory fit of the second and third hypotheses in explaining the occurrence of accidents in this group of women.

Correlation techniques were also employed by Greenwood and Woods in determining whether accidents distributed themselves by chance or whether certain individuals are more susceptible to accidents than others. For purposes of correlation the authors used the accident records of women, employed in a factory for a minimum of 8 months, and who had not been absent from work for 14 days or more during the experimental period. The accidents during two successive periods of 3 months were then correlated. The coefficients of correlation obtained in this way are shown in Table 37. There is evident in these correlations a tendency for the worker involved in accidents in one period of 3 months to increase the total number of her accidents in the next 3 months of her half year period at work. This tendency is also strikingly revealed in Table 38 showing the accident record in succeeding months of women who *did* and *did not have accidents* in the first month of the entire period during which their records were observed. It can be seen that the balance of accidents is heavily against those women who were involved in accidents during the month taken as a criterion of classification.

The results cited above are only samples of those furnished by the authors in this very conclusive study. An analysis of the results shows that the hypothesis of *Simple Chance Distribution* is entirely inadequate in explaining the distribution of repeated accidents among the members of a group. The recurrence of accidents in the case of the single individual favors very definitely the two alternative hypotheses formulated by the authors. In addition, a further analysis reveals that the method of *Unequal Liability* gives more satisfactory results, in the sense of a better fit, than do the figures obtained in the application of the method of *Biassed Distribution.* If the latter is the better explanation of the observed effects, correlations between accidents in two successive periods would be increased by eliminating from the record the individuals who sustain no accidents in the first period. Table 37 shows, however, that the elimination of women with zero accidents not only fails to increase the value of the correlation, but actually re-

duces it slightly. This fact, combined with the further analysis of the data, suggests the superiority of the hypothesis of *Distribution of Unequal Liability.*

TABLE 37

Coefficients of Correlation between Accidents in Successive Periods

DATE	OBSERVED 3 MONTHS AND PREVIOUS 3 MONTHS	NOT INCLUDING PERSONS HAVING NO ACCIDENTS IN PREVIOUS 3 MONTHS
36 Women on Heavy Lathe Operation	.69 ± .06	.63 ± .09
21 Women on Heavy Lathe Operation engaged in 1917 or earlier	.72 ± .07	.61 ± .12
29 Women on Profiling Operation	.53 ± .09	.37 ± .14
22 Women on Profiling Operation engaged in 1917 or earlier	.37 ± .12	.18 ± .17

(After Greenwood and Woods)

TABLE 38

Mean Number of Accidents per Month (Period February, 1917–July, 1918)

MONTH	136 WOMEN HAVING NO ACCIDENT IN FEBRUARY	62 WOMEN HAVING ACCIDENTS IN FEBRUARY	DIFFERENCE AND PROBABLE ERROR
February		1.31	
March	.06	.65	.59 ± .04
April	.30	.45	.15 ± .07
May	.10	.21	.11 ± .04
June	.26	.40	.14 ± .07
July	.01	.03	.02 ± .02
Total	.15	.41	.26 ± .06

(After Greenwood and Woods)

There appears good reason, in this intensive study, for the conclusion that "individual susceptibility to 'accident' is an extremely important factor in determining the distribution of accidents." . . . "So far as our present knowledge goes," write the authors, "it seems that the genesis of multiple accidents under uniform external conditions is an affair of personality and not determined by any obvious extrinsic factor." [4]

The significance of this conclusion is far reaching. It suggests the

[4] *Ibid.* pp. 9–10.

practicability of foretelling, from an experience in one period, the average allotment of accidents amongst individuals in a subsequent period. It points to the desirability of transfer, to industrial processes relatively free from accident risks, of those individuals who are particularly susceptible to accident as an additional measure in preventing accidents in industry.

The study by Greenwood and Woods represents the earliest comprehensive experimental investigation, in the industrial situation, of differences in susceptibility to accidents and of the predictive value of the number of accidents experienced by workers. The more general social implications of such relationships have been stressed by Marbe,[5] a German psychologist, whose study of the incidence of accidents among the clients of an insurance company is classic in the investigation of individual susceptibility.

Marbe studied the accident record of 3000 active commissioned and non-commisioned officers in the German army carried by a German insurance company. The subjects of the investigation were men who had carried accident insurance for a period of ten years. As a first step in the study the 3000 subjects were classified into 3 groups with respect to the number of accidents which had been reported to the insurance company during the first five years of insurance—the 3 groups being designated respectively as (a) *0 Accident* group, (b) *1 Accident* group, and (c) *Multiple Accidents* group. The average number of accidents experienced during the second 5 years of insurance by each of these groups is shown in Table 39.

TABLE 39

Average Number of Accidents During Second Five Years of Insurance

0 Accident group	0.52
1 Accident group	0.91
Multiple Accident group	1.34

(After Marbe)

A comparison was also made between the accidents during the first 2 years and the last 2 years of the insurance period. The average accidents during the last two years of the men who experienced *0* accidents during the first two years is *0.24*. The average number of accidents of men experiencing accidents in the first two years is *0.42*.

Applicants for insurance were classified by the insurance company into 3 groups with respect to the desirability of risk. The first group included those employed in office and clerical positions; the second included those on active field duty; and the third commissioned and

[5] K. Marbe, "Über Unfällversicherung und Psychotechnik," *Prakt. Psych.*, 4 (1923), pp. 257–64.

non-commissioned officers assigned to highly dangerous duty. The accidents of men with 0, 1, and more accidents in each of these sub-groups were studied. When classified in this way, as shown in Table 40, the 0, 1, and multiple accident groups were still differentiated with respect to the average number of accidents experienced in the last five years of the insurance period. This finding is of particular significance since, when classified only with respect to risk, in accordance with the standard procedure followed by insurance companies, there appears considerably less differentiation in average number of accidents than when the men are classified in accordance with the number of accidents experienced during the first two years or first five years of the insurance period.

TABLE 40

Average Number of Accidents of Diverse Risk Groups

Risk Group	Average Number of Accidents in last 5 years	2 years
1. Low Risk	0.60	0.24
2. Medium Risk	0.81	0.29
3. High Risk	0.88	0.31

(After Marbe)

Marbe's finding in this and other investigations have led him to assume the existence of a psycho-physiological predisposition toward accident which differentiates the *accident-prone* individual from one who does not suffer from repeated accidents. Marbe questions the ordinary classification according to risk by insurance companies, and points to the importance of a supplementary classification by susceptibility, as a basis for a graded scale of insurance rates determined, in part, by the number of accidents in which the individual has been involved either prior to or during the insurance period. He also indicates, particularly in a later, fuller treatment of his viewpoint,[6] the significance of differences in accident susceptibility for vocational selection. It is important, he points out, not only to select workers with respect to capability for the job but to give, in addition, considerable attention to accident susceptibility in that task as an aid in promoting vocational adjustment and in reducing the mounting cost of accidents to industry.

A report by Newbold [7] of an extensive and extremely elaborate statistical investigation, involving techniques similar to those employed by Greenwood and Woods, confirms earlier findings on the existence of accident susceptibility. The study included observation in 22 plants,

[6] K. Marbe, *Praktische Psychologie der Unfälle und Betriebschäden*, Munchen, (1926), pp. 110.

[7] E. M. Newbold, "A Contribution to the Study of the Human Factor in the Causation of Accidents," *Ind. Fat. Res. Bd. Rep.*, No. 34 (1926), pp. 74.

for periods varying from 3 months to 2 years. Firms were chosen on the basis of (a) opportunity for small accidents; (b) homogeneity of work done; and (c) strict reporting of all trivial accidents. The total number of workers observed was 8,962—6,938 men and 2,024 women—working in plants manufacturing electrical apparatus, in textile mills, in candy factories, box factories, and other types of industries.

In the case of these workers the observed distribution of accidents is in every case different from what is to be expected either on the theory of *simple chance distribution* or on the theory that accident liability is increased by accidents in the same way as susceptibility to certain diseases is increased by illness.

Among other methods, correlation between accidents in two suces-

TABLE 41

Correlation coefficients between the Accidents of the Same Workers in Two Periods

FACTORY	GROUPS	CORRELATION COEFFICIENT	NO. OF PEOPLE	LENGTH OF PERIODS (A)	(B)
D	I Females	.21 ± .15	19	2 years	5 months
D	II Females	.36 ± .09	42	2 years	5 months
E	I Males	.57 ± .02	445	1 year	1 year
E	II Males	.25 ± .04	288	1 year	1 year
E	III Males	.62 ± .03	226	1 year	1 year
E	IV Males	.20 ± .04	288	1 year	1 year
G	I Males	.36 ± .09	47	1 year	1 year
G	II Males	.57 ± .05	82	1 year	1 year
G	I Females	.53 ± .04	120	1 year	1 year
G	II Females	.01 ± .10	50	1 year	1 year
H	Females	.05 ± .05	227	6 months	6 months

(After Newbold)

sive periods of time was employed to test the thesis of *unequal liability*. In Table 41 are shown the correlation coefficients between the accidents of the same workers in two periods. It is to be seen that only the last two of the groups included in this table fail to show important correlation. These groups give similarly low values in all correlation tables presented by Newbold, owing to the fact that they have few accidents in the periods observed. In such cases, the homogeneity of the data naturally decreases the value of the correlation coefficient.

The possibility of spurious correlation in this data because of varying risk was tested, in the case of four groups in one factory, by comparing the number of accidents sustained at home with those occurring to these workers in the factory. The facts that correlation is positive in all four cases, and of the order + 0.2 to +0.3, are cited

by Newbold in evidence of the validity of the coefficients cited in Table 41. Consistent positive correlation in the case of small homogeneous samples of larger groups is also given as evidence that correlations between number of accidents during two successive periods are not spurious in character.[8]

Two groups of workers in a munition factory were found to be particularly liable to accidents from flying particles of hot metal. Coefficients of correlation between these and other types of accidents were calculated in the case of 64 of these women, whose accident records were studied in 2 successive periods of 7 months and 3 months. These coefficients again point to the stability of individual susceptibility to accidents.[9]

Among the conclusions drawn by Newbold as a result of a very painstaking analysis of a wealth of statistical data, are the following: [10]

1. The distribution of accidents among workers in all groups is far from chance. The average number of accidents in all groups is influenced by a comparatively small number of workers.

It is not possible, in the mass examination of data, to determine how much of this is due to variations in the conditions of work and how much to personal tendency, but there are many indications of the existence of individual susceptibility. This is shown by the association found between (a) accidents in two different periods (b) accidents of one type and accidents of another, and (c) accidents in the factory and accidents at home.

2. The hypothesis that the occurrence of one accident makes the occurrence of others either more or less likely does not fit the observations made in the course of the study. *It appears that the hypothesis of differing initial individual susceptibility more clearly fits the observed facts.*

Among the most important contributions of this study is a suggested method for determining, from the accident records of a department, whether the causes of accidents are mainly such as affect all the workers alike, or whether accidents are due particularly to the presence of accident-prone individuals in the group or to some special risk affecting only a portion of the workers in the department.

According to Newbold a rough approximation to an answer can quickly be obtained by finding the percentage of people in the department who have no accidents, and by reading from the table shown on page 344 what the mean number of accidents per person should be if all were exposed to the same risk.

"If it is found that the observed mean is greater than the theoretical mean obtained from this table, then it is probable that the number of acci-

[8] *Ibid.*, p. 56.
[9] *Ibid.*, p. 56.
[10] *Ibid.*, pp. 60–61.

dents in the department is unduly affected by the few people who have many accidents, and observations and experiment among these few may result in finding where the cause is. For instance, in Factory A, Group II, the percentage of men having no accidents is 24.43. This gives an ex-

Newbold's Table for a Rough Determination of the Existence of Inequality of Accident Risk in a Department

PERCENTAGE OF PERSONS HAVING NO ACCIDENTS $100e^{-m}$	CORRESPONDING MEAN NO. OF ACCIDENTS PER PERSON ON "EQUAL RISK" THEORY m	PERCENTAGE OF PERSONS HAVING NO ACCIDENTS $100e^{-m}$	CORRESPONDING MEAN NO. OF ACCIDENTS PER PERSON ON "EQUAL RISK" THEORY m
90.0	.1054	2.25	3.7942
85.0	.1625	2.00	3.9120
80.0	.2231	1.80	4.0174
75.0	.2877	1.60	4.1352
70.0	.3567	1.40	4.2687
65.0	.4308	1.30	4.3428
60.0	.5108	1.20	4.4228
55.0	.5978	1.10	4.5099
50.0	.6931	1.00	4.6052
45.0	.7985	.90	4.7105
40.0	.9163	.80	4.8283
35.0	1.0498	.70	4.9618
30.0	1.2040	.60	5.1160
27.5	1.2910	.50	5.2983
25.0	1.3863	.40	5.5214
22.5	1.4917	.35	5.6550
20.0	1.6094	.30	5.8091
17.5	1.7430	.275	5.8962
15.0	1.8971	.250	5.9915
12.5	2.0794	.225	6.0968
10.0	2.3026	.200	6.2146
9.0	2.4079	.180	6.3200
8.0	2.5257	.160	6.4378
7.0	2.6593	.140	6.5713
6.0	2.8134	.120	6.7254
5.0	2.9957	.100	6.9078
4.5	3.1011	.090	7.0131
4.0	3.2189	.080	7.1309
3.5	3.3524	.070	7.2644
3.0	3.5066	.060	7.4186
2.75	3.5936	.050	7.6009
2.50	3.6889	.040	7.8240

pected mean of about 1.4 accidents per person. The observed mean in this group is 3.78, which is therefore considerably higher than it should be judged by the number who escape accident altogether.

"If on the other hand the observed mean is not higher than that deduced from the zero group, then it is probable that the accidents that occur are not so much due to individual differences either of work or temperament, but that the causes lie in the general type of work or environment which is common to all the workers in the group, and the remedy lies in looking to these conditions." [11]

If the observed mean is higher there still remains the problem of determining whether it results from unequal risk or from an excess of accident-prone individuals in the department. The measures taken to correct the disproportionate number of accidents will, of course, depend upon the results of this analysis. The application of the method, as Newbold clearly indicates, must be made cautiously, because it assumes that the plant is divided into fairly homogeneous departments from the viewpoint of accident risk, that standards of reporting accidents are uniform, etc. In spite of these factors, the approach is extremely suggestive.

In addition to these more general studies of distribution of accidents there has been a number of investigations of differences in accident susceptibility among workers in specific occupations. Schmitt [12] has investigated in the railway industry the applicability of what is being called in Germany *"Marbe's Law"* or the *"Law of Recurrence"*—that the probability that an individual will experience an accident can be determined from the number which he has already sustained. The results of this study confirm the relationship between earlier and later accidents occurring at work found in other investigations. An additional significant feature of the study is the finding, also appearing in Newbold's study,[13] that a relationship exists between industrial accidents and those sustained when the employee is off duty. A survey of personal injuries sustained outside of the plant also shows that the law of recurrence applies as well to these as to industrial accidents. This is indicated in the records of 411 workers employed in the same location between the years 1913 and 1924. Employees who are involved in 0 accidents during the first six years of employment have an average accident rate of 0.32 during the second six years. Employees with 1 accident during the first period also have an average of 0.32 accident during the second six year period. Employees with *multiple* accidents (2 to 5) have an average of 1.06 accidents during the second year of employment.

The existence of Marbe's Law in the industrial situation has also

[11] *Ibid.*, pp. 25–27.
[12] E. Schmitt, "Unfällaffinität und Psychotechnik im Eisenbahndienst," *Ind. Psychot.*, 3 (1926), pp. 144–153; 364–366.
[13] E. M. Newbold, *op. cit.*, p. 57.

been demonstrated by Hildebrandt,[14] who examined the accident records of 200 women employed in a large plant between the years 1920 and 1925. A comparison of accident records during the first 3 years of this period with those sustained during the last 2 years give the results shown in Table 42.

TABLE 42

Comparison of Accidents During Two Periods
1920–1925

NO. OF WORKERS	NUMBER OF ACCIDENTS DURING THE FIRST 3 YEARS	AVERAGE ACCIDENTS DURING THE LAST 2 YEARS
154	0	0.38
38	1	0.52
8	2 or more	1.37

(After Hildebrandt)

In spite of the few cases, the characteristic relationship between earlier and later accidents is again found to be unmistakably present.

The Nature of Susceptibility to Accidents

The fact that individuals differ in susceptibility to accidents has been firmly established in the investigation described above. From this observation grows a second problem, that of determining the measurable respects in which susceptible or *accident-prone* individuals differ from their fellows. This problem has been made the subject of a preliminary study by Farmer and Chambers.[15]

For the purposes of this study an accident was defined as attendance at the factory surgery for reasons other than sickness or redressing as a result of an injury incurred in the plant. Six hundred and fifty-one subjects were included in the investigation. Of these 611 were apprentices and 40 were women factory workers. The distribution of subjects with respect to occupation, sex, age, number of accidents, and the period of study for each group are shown in Table 43.

Three groups of tests were applied to these subjects.

Group I included three tests: (1) *dotting test,* (2) *reaction time* test, and (3) *pursuit meter,* designated by the investigators as tests of *aestheto-kinetic* co-ordination. Essentially these are tests in which a stimulus perceived through a specific sense organ is to be interpreted by the subject as a sign for varying muscular performance of hand, arm, or other part of the body.[16]

[14] H. Hildebrandt, "Zur Psychologie der Unfällgefahrdeten," *Psychot. Z.,* 3 (1928), pp. 1–8.

[15] E. Farmer and E. G. Chambers, "A Psychological Study of Individual Differences in Accident Rates," *Ind. Fat. Res. Brd. Rep.,* No. 38 (1926), pp. 46.

[16] See Chapter XII, pages 234–35.

Group II likewise consisted of three tests, including (1) *tests of muscular balance*, (2) *tests of tremor*, and (3) *psycho-galvanic reflex test*. These are described by the authors as indices of *temperamental instability*.

Group III consisted of (1) an *intelligence test* and (2) a *number*

TABLE 43

Details of Groups Tested by Farmer and Chambers

GROUP	NO.	SEX	AGE: AVERAGE	AGE: RANGE	ACCIDENTS: AVERAGE	ACCIDENTS: RANGE	EXPOSURE (MTHS)
A . Employed in Sweet Covering	17	F	17.1	16–20	1.7	0–10	12
B . Employed in Packing Sweets	23	F	17.6	14–23	6.9	0–31	12
C . Dockyard Apprentices employed as shipwrights, plumbers, joiners, coppersmiths, and electrical engineers	57	M	16.9	16–18	0.59	0–7	24
D . . Dockyard Apprentices employed similar to Group C	100	M	15.8	15–17	0.33	0–5	12
E . . Royal Air Force Apprentices employed as carpenters, engine fitters, riggers, motor body builders, and coppersmiths	175	M	18.8	17–20	0.64	0–18	36
F . . Royal Air Force Apprentices who had just commenced training and were employed similarly to Group E	279	M	16.1	15–17	0.47	0–4	9

(After Farmer and Chambers)

setting test. These are tests of the higher thought processes measured with a scholastic medium in the intelligence test and through a mechanical medium in the number setting test.

For purposes of comparison each group of workers was divided with respect to each test, into *sub-groups*, one including those whose scores were above the mean in the test, known as the *Better Sub-group*, and the second including those whose scores were below the mean in each test, known as the *Worst Sub-group*.

The character of the results obtained is to be seen by reference to

Table 44, showing the accident rates of the "Better Sub-group" and the "Worse Sub-group" in the dotting test.

Among the most important findings is the observation that those who obtain passing weighted scores on the three tests of aestheto-kinetic co-ordination had an average accident rate of 48 per cent less than those who failed. Constant results obtained on these tests from all 6 groups suggest that the predictive value of these particular tests cannot be improved, but they also point to opportunities for more marked accomplishment through the development of more refined instruments for measuring the essential qualities of individuals who are susceptible to accidents.

TABLE 44[17]

Accident Rate Expressed as a Percentage of the Mean of those Better and Worse than the Average in the Dotting Test

Group	Better in Test		Worse in Test
A	41		153
B	90		112
C	71		122
D	76		124
E	79		123
F	72		126
Weighted Averages	74		125
Difference		+ 51	
Probable Errors of Difference		12.0	

(After Farmer and Chambers)

In discussing the results, the authors state very clearly the limitations of the tests employed, most particularly with respect to techniques employed in the measurement of temperament. They point out that the reliability of the tests have not been established and that, until this is done, the tests cannot be safely used in predicting individual susceptibility to accidents. However, they feel justified, on the basis of results, in drawing the following conclusions concerning the nature of individual susceptibility to accidents.[18]

(1) The results permit the conclusion to be drawn that inequality in accident liability is not solely determined by external factors or by chance, but is due in an appreciable degree to measurable individual differences.

(2) The findings suggest that it is practicable to determine in a rough way the probability of any individual sustaining an undue num-

[17] E. Farmer and E. G. Chambers, *op. cit.*, p. 17.
[18] *Ibid.*, p. 36.

ber of accidents, and as more research work is done and the methods become more refined, this probability should tend more and more to approximate certainty.

(3) The experimental data shows the existence, in the subjects examined, of a relationship between accidents on the one hand, and poor aestheto-kinetic co-ordination and nervous instability on the other. No relation was found in this study between accident rate and the higher intellectual processes.

The investigators point out that their findings must not be accepted as evidence of the presence of a general factor in personal proneness to accidents, and that no attempt has been made to distinguish between specific and general factors in individual susceptibility—a distinction that will have to be examined in further studies.

The validity of these findings and conclusions has been examined by Farmer and Chambers [19] in a second study involving 1800 subjects employed in diverse occupations. In industrial groups where adequate accident records were available it was found that the lowest 25 per cent in a combined and weighted battery of intelligence and aestheto-kinetic tests had an accident rate 2.5 as great as the remaining 75 per cent. An extremely significant finding in this study is the observation that the correlation between the psychological tests and accident rates increases with increased length of exposure to accident. This indicates the importance of early transfer of the accident-prone employee, in whose case exposure to risk appears to be associated with increasing effectiveness of the accident prone qualities.

Another interesting finding of the investigation is the fact that the tests which were useful in selecting those least prone to accidents also picked those who were most proficient in their jobs. "This conclusion is of value for practical purposes, for it means that if these tests were used for vocational purposes a group of workers would be selected by them who on the whole would be more proficient at their work and have fewer accidents than those rejected by the tests, so that the use of these tests would serve a dual purpose and increase industrial efficiency in two different ways." [20]

The size of the coefficients of correlations between psychological tests and accident rates, and other findings in this study, as well as in earlier studies [21] show that there are determinants in accident proneness other than intelligence and aestheto-kinetic co-ordination. Accident-proneness or individual susceptibility to accident appears to be a combination or pattern of many factors, all of which require considerably more detailed investigation.

[19] E. Farmer and E. G. Chambers, "A Study of Personal Qualities in Accident Proneness and Proficiency," *Ind. Fat. Res. Bd. Rep.*, No. 55, 1929, pp. 84.

[20] E. Farmer, "Psychological Study of Accident Proneness," *Pers. Jour.*, 9 (1930), pp. 115–120.

[21] E. M. Newbold, *op. cit.*

SPECIFIC FACTORS IN SUSCEPTIBILITY TO ACCIDENT

1—*Age and Experience*

In a number of the studies cited above, as well as in others, an attempt has been made to isolate the influence of specific factors other than strictly mental traits in accident susceptibility. So, for example, the influence of *age* has been examined in a number of inquiries. An investigation in a Connecticut textile mill shows a consistent decrease in accident rate per 100 workers from *30,* for workers between 15 and 20 years of age to *12* per 100 for workers between 30 and 35 years of age.[22]

In the same study multiple accidents were found to appear more frequently among younger than older workers. Gates [23] reports a similar inverse ratio between age and accident rates of textile mill workers. Schmitt [24] and Lipmann,[25] in Germany, present evidence of a higher frequency of accident among younger workers. Greenwood and Woods [26] report low negative correlations (—.2) between age and accidents, but the small number of cases and high probable errors make these findings, to quote the authors, "of no practical importance."

The influence of age tends to be closely related to that of experience, inasmuch as the younger workers tend to be the less experienced workers in the plant. Newbold,[27] making use of the method of partial correlation in distinguishing between the influence of age and experience, reaches the conclusion that accidents tend to decrease with age but not with experience, when an allowance is made for age. In other words, when age is kept constant, the association between decreased accident rate with increasing length of service tends to vanish. On the other hand, when the length of service is kept constant, the relation between decreased accident rate with increasing age remains undisturbed, showing the latter to be a stronger tendency. Newbold also shows these findings to be consistent with the observed increase in *fatal* accidents with increasing age by evidence that the latter is a factor of increased susceptibility to death from all causes with increasing age.

The data on the influence of age is meagre, and it is somewhat confused by such variables as the existence of less hesitation on the part of young people in reporting accidents, but the trend of available evidence favors the common practice of excluding younger people from extra-hazardous occupations.

[22] A. Hewes, "Study of Accident Records in a Textile Mill," *J. Indust. Hyg.*, 3 (1921), 6.
[23] D. S. Gates, "A Statistical Study of Accidents in the Cotton Mills, Print Works and Worsted Mills of a Textile Company," *J. Indust. Hyg.*, 2 (1920), 8.
[24] E. Schmitt, *op. cit.*
[25] O. Lipmann, *Unfällursachen und Unfällbekampfung*, Berlin, 1925.
[26] M. Greenwood and H. M. Woods, *op. cit.*, pp. 25–26.
[27] E. M. Newbold, *op. cit.*, pp. 27–41.

The suggestive findings of Newbold[28] on the relative influence of age and experience are in conflict with common opinion on the effect of experience on accident rate. According to Fisher,[29] for example, "inexperience is a prolific source of accident." As evidence of this he points to a gradual reduction of accident rate with increasing length of service among workers in a textile mill (Table 45). The decrease in rate from year to year is consistent until the level of more than 30 years of service is reached. The same author cites an unpublished study of accidents in the Carnegie Steel Company, Youngstown Sheet and Tube Company, International Harvester Company, Fairbanks, Morse, and several other companies, which showed employees with

TABLE 45

Rate of Accidents in Proportion to the Average Number of Employees in Each Length of Service Group

LENGTH OF SERVICE	NO. OF EMPLOYEES	NO. OF ACCIDENTS	ACCIDENT RATE
Less than 1 month	41	74	181%
1 to less than 3 months	96	121	127
3 " " " 8 "	249	217	87
8 " " " 12 "	183	114	62
Total less than 1 year	569	526	92
1 to under 5 years	750	430	57
5 " " 10 "	267	125	47
10 " " 20 "	223	119	53
20 " " 30 "	164	59	36
30 " " 40 "	75	33	44
40 " " 50 "	33	22	67
50 " " 60 "	4	0	0

(After Fisher)

less than one month's service to be 6 times as liable to injury as those with more than one month's service.

Differences in accident rate between inexperienced and experienced workers appear in a study made by the United States Bureau of Mines[30] which shows that, in the case of two large mines, 48.1 per cent of injuries occurred during the first two months of employment and that 20.5 per cent occurred during the first week. This is in accord with the findings of an earlier investigation of 48 industrial plants in Illinois,[31] which showed that employees of less than six months'

[28] *Ibid.*
[29] B. Fisher, *Mental Causes of Accidents,* New York, 1922, p. 34.
[30] Cited in *The American Labor Legislation Review,* Sept., 1924, p. 249.
[31] "Hours and Health of Women Workers," *Report of the Illinois Industrial Survey,* (1918), p. 102.

experience, constituting approximately 35 per cent of the total working force, accounted for 60 per cent of the total number of industrial accidents. Evidence pointing to an adverse effect of inexperience upon accidents is also found in a report by Chaney and Hanna [32] on accidents in the iron and steel industry. Dussier [33] also reports accidents among factory workers with less than one year of service to be more than double that of other workers in the plant.

Such data suggests that experience is a factor in accident causation. However, there is need for a very intensive analysis of this relationship to determine more exactly the influence of age, of levels of proficiency, of selection, of temperamental reaction to new surroundings and conditions of work, and of other mental factors which may be concealed in a general cover-all of experience.

Physical Condition

Susceptibility to accident may be the end result of a combination of forces reflecting a generally lowered physiological effectiveness of the kind that causes or appears in frequent *illness*. A positive correlation between minor sickness and accidents (of the order of +.3) is reported by Newbold. Sickness was measured by the number of reports to the medical dispensary because of sore throat, headache, biliousness, and for similar reasons. The suggestion from the data, given in some detail by the author, is that "these small ailments are a measure of lower general health—and that the tendency to accidents is associated with such a state." [34]

Newbold also compared accident rate with absences by reason of sicknesses and found a negligible correlation. The absence of correlation when days absent is used as a criterion of sickness is confirmed in the later study by Farmer and Chambers,[35] who find only one coefficient above .13 in a comparison of days lost because of sickness and accident rate. In explaining the apparent discrepancy when the second criterion of illness is used, it is suggested that frequent visits to the medical dispensary are in part occasioned by the same type of temperamental instability which plays a part in accidents. Sickness involving loss of time is said to be relatively free from the influence of this factor. It will also tend to occur more among the old than the young, and so (by reason of the negative correlation between age and accident rate) there can be expected only negligible correlation between time lost through illness and accidents.

Indications of a relationship between physical condition and acci-

[32] L. W. Chaney and H. S. Hanna, *The Safety Movement in the Iron and Steel Industry, 1907–1917*, Bureau of Labor Statistics, Washington, 1918, Rep. No. 254.

[33] H. Dussier, "Les Accidents du Travail et le Systeme de Prevention Appliqué dans les Usines Luxembourgeoises des Societies Arbed et Terres Rouges," *Revue de la Science du Travail*, 2 (1930), p. 93.

[34] E. M. Newbold, *op. cit.*, p. 45.

[35] E. Farmer and E. G. Chambers, *op. cit.*, p. 34.

dents appear in a recent unpublished study by the author of electrical substation operators. All operators and senior operators employed by Philadelphia Electric Company, 135 in number, were re-examined by the Medical Department in the months of October and November,

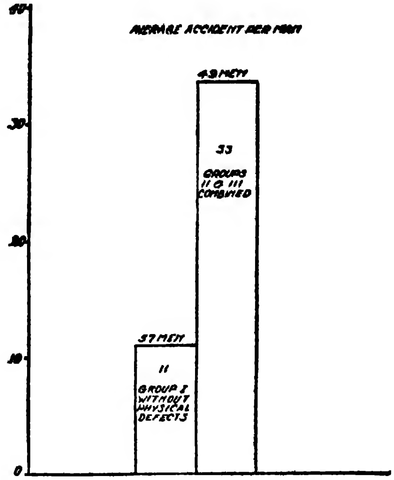


FIGURE 47. *Comparison of Medical Ratings with Operating Errors and Accidents 106 Operators and Senior Operators Hired Prior to Jan. 1, 1926*

(From an Unpublished Study by the Author)

1929. Of these, 106 operators, hired prior to January 1, 1926, were included in this study.[30]

On the basis of the medical examination the company physician classified these employees into the following groups:

Group I—Without Physical Defect
Group II—With Physical Defect
Group III—Not Fitted for Present Position

Of the 106 operators and senior operators 57 were placed in Group I, 31 in Group II, and 18 in Group III.

An analysis has been made of the lost time accidents of these employees for a period of ten years preceding the date of the examination. The results of this analysis are shown in Figure 47, in which the average lost time accident per man in Group I, *Without Physical Defect,* is compared with the average lost time accident per man of

[30] The remainder were omitted because records on operating errors were available only subsequent to that date, and, since a comparison was also being made with operating errors, it was considered well to include only those who were in a position to be involved in errors throughout the entire period subsequent to that date.

the men found to be suffering from some physical defect. (Group II—*With Physical Defect* and Group III—*Not Fitted for Present Position*). The average lost time accident per man among those suffering from physical defects is found to be 3 times as high as that of men not suffering from physical defects.

The possible influence of age and experience has been investigated by finding the average age and length of service of these groups. The average age (38.5) of those suffering from some degree of physical defect is found to be six years above that of men without physical defect (32.5). The average length of service (148.2 months) of the former is found to be approximately three years longer than that of men without physical defect (115.3 months). These differences do not appear to be significant, although, in the light of the studies, the greater age and length of service would tend to reduce the lost time accidents of the men (Groups II and III) who have the poorer lost time accident record. It seems possible to conclude, from the available data, that the greater average number of lost time accidents of men with some degree of physical defect can be referred to the general physical inferiority of these men.

There is much need for additional studies of this kind. As in the case of age and experience the general data on the relation of illness to accident-proneness is far from adequate, but again there are suggestions of a trend.

The findings on age, experience, and illness cited above are only suggestive of factors other than mental traits which must be investigated in determining the nature of susceptibility to accidents. *Race, the effect of education in safety during childhood, the influence of specific habits developed through training,* represent other factors which must be investigated in the complete analysis of accident-proneness.

3—Nationality

It is possible, for example, that certain racio-national groups are more susceptible to injury than others. The author has investigated this in the case of personal injuries occurring to drivers employed by a taxicab corporation—the *Parmelee System, Inc.*—of New York City. The injuries in this study do not include personal injuries sustained by pedestrians or by passengers, but only those sustained by drivers which make them eligible for accident compensation. A large proportion of these accidents is not the result of collision, but includes falls, cuts, and bruises sustained while on duty, but not necessarily while engaged in the operation of a cab.

The investigation covers 497 compensation reports turned in by drivers during the months of August to November, 1931, inclusive. These include all but 62 of the compensation reports made during this period. Of these 62 reports, 46 were discarded because they involved

shop mechanics and garage help whose records were not available for study. The remaining cases were discarded because of the inadequacy of information furnished on the application blank filled in by the driver at the time of employment.

For the purpose of this study the drivers were classified into three racio-national groups, each group being defined as follows:

	Number
Group A. Hebrew—members of the Hebrew race regardless of the place of birth	213
Group B. Italian—those born in Italy or whose parents were born in Italy	57
Group C. All Other Nationalities—including all groups not listed above	227

(Under *All Other Nationalities* are included 174 native born Americans, and 53 of other national origins.)

It is obvious that the classification is entirely arbitrary in character. It was intentionally made so by reason of the interest in studying primarily the compensation status of Groups A and B. A comparison of compensation reports showed that whereas the Hebrews constitute approximately 43 per cent of the working force, they were involved in 42 per cent of accidents reported during the period studied. Italians, constituting approximately 12 per cent of the working force were responsible for approximately 15 per cent of these accidents, and "All Others," constituting about 45 per cent of the working force turned in approximately 43 per cent of the compensation reports. It is quite evident that each group furnishes approximately that percentage of compensation reports that is to be expected on the basis of chance, inasmuch as the percentage is almost identical with the proportion of each national group on the drivers' payroll.

A comparison was also made of estimated compensation and medical costs of injuries reported by each of these national groups. The estimated costs are furnished by an organization specializing in compensation service which handles all compensation claims for the taxicab corporation. It has been found that the estimates made for such costs are in the aggregate very close to the sum actually expended in providing medical costs and settling compensation claims. As a matter of fact, experience has shown these estimates to have approximately the same degree of accuracy as actuarial estimates made by life insurance companies.

Estimated average compensation and medical costs vary from an average of $62.69 for the Hebrew to $74.06 for All Other Nationalities. For the Italian it is $70.21, and for the entire group of employees it is $68.07. The difference of $12.00 between the average of the best and worse groups does not seem great, but this difference in average represents an excess of almost $3500.00 for All Other National groups

as compared with Hebrews during the four months period covered by this study.

No attempt has been made to calculate the significance of the differences. The author presents these figures merely as suggestive in the investigation of another factor, that of racio-national differences, which must be submitted to experimental investigation in the study of accident proneness.

In so far as injuries in manufacturing plants are concerned little has been done in the analysis of factors other than those discussed above. In the study of susceptibility to accidents or collisions on the part of motor vehicle operators some attempt has been made to determine the influence of these other factors. These studies will be briefly referred to in Chapter XVIII, devoted to the prevention of accidents in the transportation industry.

FACTORS AFFECTING ACCIDENT LIABILITY

1—*Fatigue*

In an earlier section of this chapter the distinction has been drawn between non-machinery accidents resulting from personal predisposition and those which represent the influence of machine or plant conditions. Farmer and Chambers [37] have distinguished between "accident-proneness" and "accident liability," using the first term to indicate personal predisposition and the second to include all the factors which affect accident rate. Among these would be such conditions as hours of work, illumination, ventilation, speed of machine and rate of work, etc. Among the specific factors associated, in part at least, with plant and working conditions which affect accident rate, is *fatigue*. The general aspects of fatigue are treated in Chapters XXI and XXII, but it is necessary also to give it specific consideration in relation to industrial accidents.

Investigations both in the United States and Europe have shown that accidents tend to increase with each successive hour of work in the morning, reaching a maximum at approximately 11 A. M., and falling toward zero at the noon hour. The number and rate rise again sharply following the noon hour, reaching a peak toward the latter part of the afternoon, but dropping off somewhat during the last hour of work. This typical distribution of accidents during the day is shown in Table 46, combining results from the records of 19 plants engaged in metal manufacturing and 126 cotton mills for a period of one year; one cotton mill for a period of eight years; the unpublished records of the Indiana Department of Factory Inspection for three years, and the tabulation of the Wisconsin Bureau of Labor.[38] The

[37] E. Farmer and E. G. Chambers, *Ind. Fat. Res. Bd. Rep.* No. 38, p. 3.

[38] "Report on the Condition of Woman and Child Wage Earners in the United States," Vol. XI, *Employment of Women in the Metal Trades,* Senate Doc. No. 645, 61st Congress, 1911.

TABLE 46

Distribution of Industrial Accidents Through the Hours of the Day

HOURS	COTTON MILLS				GENERAL MANUFACTURE				METAL-WORKING ESTABLISHMENTS		GRAND TOTAL	
	126 MILLS 1 YEAR		1 MILL 8 YEARS		INDIANA 3 YEARS		WISCONSIN		TOTAL			
	NO. OF ACCIDENTS	PER CENT	NO. OF ACCIDENTS	PER CENT	NO. OF ACCIDENTS	PER CENT	NO. OF ACCIDENTS	PER CENT	NO. OF ACCIDENTS	PER CENT	NO. OF ACCIDENTS	PER CENT
6 to 7 A. M. ..	73	6.19	63	8.22		. . .	.	. . . .	. . .	. . . .	136	0.91
7.01 to 8 A. M. ...	95	8.05	68	8.88	546	11.31	76	4.02	486	7.81	1,271	8.53
8.01 to 9 A. M.	126	10.68	82	10.71	492	10.19	126	6.67	677	10.87	1,503	10.09
9.01 to 10 A. M.	**161**	**13.64**	90	11.75	**603**	**12.49**	227	12.01	**860**	**13.81**	**1,941**	**13.04**
10.01 to 11 A. M.	128	10.85	**114**	**14.88**	469	9.71	**245**	**12.96**	763	12.25	1,719	11.54
11.01 to 12 M.	78	6.61	43	5.61	338	7.00	208	11.00	491	7.89	1,158	7.78
12.01 to 1 P. M.	58	4.92	9	1.18	183	3.79	49	2.59	241	3.87	540	3.63
1.01 to 2 P. M.	78	6.61	63	8.22	441	9.13	126	6.67	602	9.67	1,310	8.80
2.01 to 3 P. M.	98	8.30	67	8.75	481	9.97	213	11.27	676	10.86	1,535	10.31
3.01 to 4 P. M.	**126**	**10.68**	**77**	**10.05**	**598**	**12.38**	**240**	**12.70**	**716**	**11.50**	**1,757**	**11.80**
4.01 to 5 P. M.	90	7.63	57	7.44	480	9.95	229	12.12	511	8.21	1,367	9.18
5.01 to 6 P. M.	59	5.00	33	4.31	197	4.08	151	7.99	203	3.26	643	4.32
6.01 to 7 P. M.	7	.59	. . .	. . . .	. . .	. . . .	. . .	. . . .	. . .	. . . .	7	.05
7.01 to 8 P. M.	3	.25	. . .	. . . .	. . .	. . . .	. . .	. . . .	. . .	. . . .	3	.02
Total	1,180	100.00	766	100.00	4,828	100.00	1,890	100.00	6,226	100.00	14,890	100.00

From J. Goldmark, *Fatigue and Efficiency*, New York, 1912, Part II, p. 211.

typical character of this relation between hours of work and number of accidents also appears in an early French study of the incidence, according to hours, of 3,352 accidents occurring during 1904 in plants located in 5 provincial departments of France.[39]

More recent statistical studies, as well as investigations in other countries, confirm the findings of these early investigations on the hourly distribution of accidents. A comparison of the hourly distribution of accidents with the typical production curve, Figure 61, will show that in a normal working day accident rate varies with the rate of production, being highest when production is highest and lowest during the hours of lessened production.

There has been considerable controversy over the part played by fatigue in this situation. The traditional tendency has been to explain the increase in accident rate with progressive hours of work as the result of fatigue.[40] "We know," writes Goldmark, "that even in the healthiest organism the products of fatigue accumulate with progressive hours of work; we know that our promptitude of reaction rises and falls with the freshness of our attention; that nothing is more potent than fatigue to increase reaction time and develop muscular inaccuracies.

"Hence when we find the number and ratio of accidents increasing up to a certain point with each successive hour of work during the morning, falling towards zero at the noon hour and again rising toward a maximum in the afternoon, it is reasonable to ascribe the increase in large part to the effects of fatigue, direct and indirect." [41]

The drop in rate in the last hour of the morning and afternoon period, when the worker may be expected to be most fatigued, is explained by the reduced rate of production which occurs, with increasing fatigue, in the last hours of work. The slackening of speed brings with it a decrease in the accident rate. The effects of fatigue upon accident rate are thus explained as being both direct and indirect—both positive and negative in so far as influence upon accident rate is concerned.

In contrast with the traditional viewpoint that fatigue is the determining factor producing the characteristic increase in number of accidents in the course of the working day is the emphasis by Vernon [42] upon varying speeds of production and upon mental factors in explaining the variations in accident rate throughout the day. Ac-

[39] M. A. Imbert and M. Mestre, "Hygiène Publique, Nouvelles Statistiques d'accidents du Travail," *Rev. Scient.*, 1905.

[40] A. Imbert, "Les Accident du Travail et les Compagnies d'Assurance," *Rev. Scient.* (June, 1904), 15; M. LeRoy, *Bulletin de l'Inspection du Travail et de l'Hygiène Industrielle*, 3, 4 (1906), p. 219.

[41] J. Goldmark, *Fatigue and Efficiency*, New York, 1912, p. 72.

[42] *First Interim Report*, Committee on Fatigue from the Economic Standpoint, 1916. H. M. Vernon, "An Investigation of the Factors Concerned in the Causation of Industrial Accidents," *Health of Munitions Workers Committee, Memo.*, No. 21 (1918), pp. 46; H. M. Vernon, *Industrial Fatigue and Efficiency*, London, 1921, pp. 264.

cording to the latter "the strong qualitative resemblance between the rate of output curve and the accident incidence curve during the day shift shows that the varying speed of production is largely responsible for the day shift variations of accidents, and *not* fatigue." [43] In addition, he insists that mental factors such as alertness or attention play an important part in determining the accident rate through the day.

The hypothesis that mental factors affect accident rate is based on a comparison between the accident rate on day shifts and accident rate on night shifts. In the former, the accident curve follows the output curve very closely; in the latter, it is widely different. During the night shift the accident rate is at a maximum at the beginning of the working spell and then falls sharply until it reaches approximately one half its original value. The lowest accident rate occurs at the very end of the work spell in the night shift. The total accident rate on the night shift was found in one study to be approximately 15 per cent lower than during the day shift, with no decrease in output.

Vernon ascribes these differences to the fact that the worker on the day shift becomes inattentive toward the end of the day's work, as his mind wanders toward the prospect of an evening's entertainment, or toward activities in which he will engage upon leaving work. The night worker starts the day in a careless and excited state of mind, but gradually settles down to a calmer mental state, which reaches its most profound level at the very end of the night shift, as the worker looks forward to the morning sleep which he will enjoy immediately upon returning from work.

The United States Public Health Service undertook to examine the hypothesis [44] that hourly variations in accident rate depend upon variations in production rather than upon fatigue by an investigation of 46,000 accidents in two metal manufacturing plants. An index was compiled showing the hourly accident rate per unit of output. If fatigue plays no part, this should always remain constant, regardless of the rate of output and of the hour of day. As a matter of fact, the result shows a marked increase in the index figure at the end of the working spell, reflecting an increase in the accident rate per unit of output, in spite of the decline in the absolute accident rate. This finding is accepted as evidence that fatigue is the determining factor in hourly variations in accident rate.

This conclusion is still questioned by Vernon because of the failure of the investigators to consider the subjective or psychic factors, referred to above, in accident causation. The significance of this factor

[43] "Two Contributions to the Study of Accident Causation," *Ind. Fat. Res. Brd. Rep.*, No. 19, (1919), p. V.

[44] "A Comparison of an Eight Hour Plant and a Ten Hour Plant," *Public Health Service Bulletin*, No. 106, (1920), also "Industrial Accidents," *Monthly Labor Review*, (May, 1920), p. 161.

is demonstrated in an investigation in a munition plant conducted by Osborne and Vernon.[45] The data deals with flesh cuts treated in a period of approximately a year in a projectile factory. The number of cuts totaled 2,560 in the case of the men and 3,409 in the case of

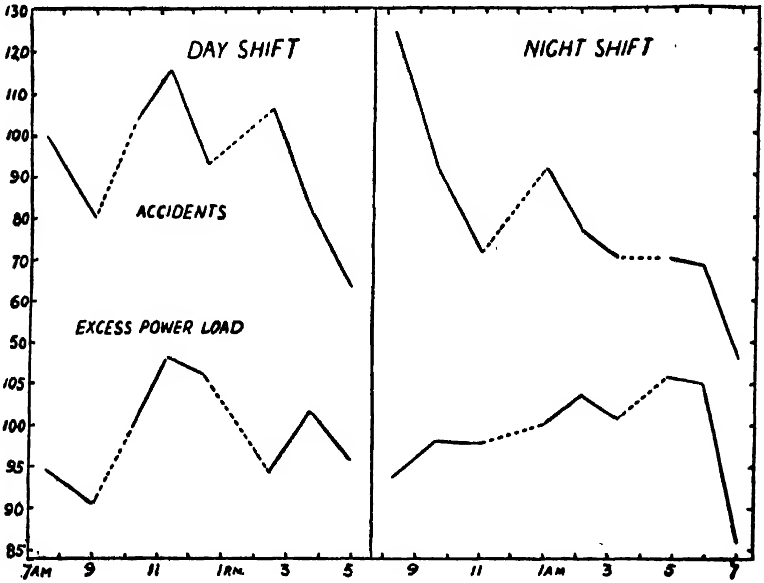


FIGURE 48. *Accidents in Relation to Output*

(*After Osborne and Vernon*)

the women. The working force was divided into a day shift, working from 7:15 A. M. to 5:15 P. M., and a night shift employed from 8:00 P. M. to 7:15 A. M. In order to overcome variations in lunch hours and the effect of accidents occurring during the first few minutes and last few minutes of work, day shift accidents were computed for the hours 7:30 to 9:00 A. M., 10:15 to 12:30 P. M. and 2.30 to 5:00 P. M. Night shift spells were divided on the same principle.

Figure 48 shows the incidence of cuts during various hours of the day shift and night shift. The lower curve in each figure shows the variations observed in the electric power load required to drive the whole of the plant during 48 consecutive hours during January, 1918. Power load was recorded automatically, and has been subjected to a deduction of 60 per cent of the average load throughout as an allowance

[45] E. E. Osborne and H. M. Vernon, "The Influence of Temperature and other Conditions on the Frequency of Industrial Accidents," *Ind. Fat. Res. Brd. Rep.*, No. 19, (1922), p. 17.

for the power required to drive shafting and machinery apart from utilization on actual work on shells.

Variations in power load are equivalent to output variations. It can be seen that variations in accident rate on the day shift coincide with variations in output as indicated in the power load curve. No such coincidence is shown in the case of the accident curve obtained during the night shift. Whereas accidents are at a maximum in the middle of the work spell during the day shift, they are at a maximum at the beginning of the work spell during the night shift. The accident rate also continues to fall consistently to the end of the night shift.

It appears from this, according to Vernon, that variations in night shift accidents are not due to variations in speed of production. Subjective factors are used in explanation of the differences between the two shifts.[46] It is pointed out that "the day shift workers, when they started on their work in the early morning, were in a depressed and somewhat lethargic condition, but they brightened up gradually, especially after their tea and food, at about 9 A. M., and they got into a more and more lively and careless state of mind as their dinner hour approached. The night shift workers, on the other hand, got up several hours before coming on to work, and they often spent these hours in amusement and in having substantial meals, hence they began their work in a careless and excited state; but they gradually calmed down during the course of the night, as they had nothing but an unexhilarating breakfast and bed to look forward to. These variations in the psychical state of the workers must have produced considerable variations in accident frequency, and especially so by night, when the usual effect of output variations on accident frequently was completely swamped by them, or by some other unknown factor."

The conclusions drawn in the report by the United States Public Health Service,[47] to which reference has been made, are criticized by Osborne and Vernon because of the failure to make a similar analysis. The investigators point particularly to the omission from this report of figures on accidents during night shifts, later made available by Ryan,[48] which somewhat confirm their own findings concerning differences in hourly variation of accident rate on day and night shifts.

At the same time, Osborne and Vernon recognize the influence of fatigue, and cite data in the form of reduction of accidents coincident with a reduction in the hours of work as evidence of the part which fatigue may play in the production of accidents. These figures were obtained in a 6″ shell factory. In this plant, when women worked the same 61 hour week as men, their accidents were 91 per cent as numerous. When the hours of the women were reduced to 39½ a week, their

[46] E. E. Osborne and H. M. Vernon, *op. cit.*, p. 12.
[47] *United States Public Health Service Bulletin, op. cit.*
[48] A. H. Ryan, "Discussion of Public Health Bulletin, No. 106," *J. of Ind. Hyg.*, 2 (1921), p. 466.

accidents fell to 78 per cent of those experienced by the men. These figures represent cuts per hour experienced by the men and women.

2—Rate of Production

It is evident from this discussion that *rate of production* must be given separate consideration as a factor in accident causation. This need has appeared quite clearly in a recent survey on *Safety and Production*,[49] conducted under the auspices of the American Engineering Council, to determine the cause of an increase in number and severity of industrial accidents noted subsequent to 1922. The suspicion that this increase may reflect merely an increasing tempo of production led to an extensive investigation involving approximately 1,000,000 employees in 59 industrial groups.

Chief among the conclusions of this investigation is that, if production is used as the criterion, there has actually been a marked decrease in the incidence of accidents in American industry. There is evidence that increased production is associated with an increased *number* and severity of accidents, but that the *proportion* of accidents tends to decrease with increasing production. "The rate of change in production per man-hour for the industrial groups studied is greater than the rate of change in accident frequency per man-hour or the rate of change in accident severity per man-hour. Quantitatively, the production rate was 14.4 per cent higher in 1925 than in 1922, the accident-frequency rate 10.4 per cent lower in 1925 than in 1922, and the accident-severity rate 2.5 per cent higher in 1925 than in 1922." This may suggest that increased rate of production favors accident reduction, but it is evident that increased production in the industries studied is primarily associated with increased mechanization and not necessarily with an increase in the rate of work on the part of those employed. In addition the evidence indicates that the decrease in accidents in a given plant bears direct relation to the over-all efficiency of the plant. A cutting edge that is kept clean not only cuts faster and better but it is less apt to cause accidents by breakage or by projecting particles of steel in the direction of the worker.

The effect of rate of work on safety requires investigation under controlled conditions. Characteristic of studies in this field is Muscio's [50] analysis of the effect of varying rates of speed on accuracy in Aiming and in Pendulum Tests. The procedure with the Aiming test, a section of which is illustrated in Figure 49, was to spear at the targets with a dissecting needle held vertically in the right hand, the arm being unsupported. The target sheets were placed on a cardboard holder lying flat on a table in front of the subjects, who worked while seated. The subject aimed at each target in order for 3 suc-

[49] *Safety and Production*, New York, 1928, pp. 414.
[50] M. A. Muscio, "On the Relation of Fatigue and Accuracy to Speed and Duration of Work," *Ind. Fat. Res. Brd. Rep.*, No. 19, (1922), pp. 18–36.

cessive trials. The aiming was done in rhythm with the beat of a metronome. Six rates, varying from 60 to 210 beats per minute, were employed in testing the effect of rate of work upon accuracy. The order of rates was varied with the various subjects in order to make constant the effect of practice. The average accuracy obtained by the six subjects for each rate of work is shown in Table 47, which gives

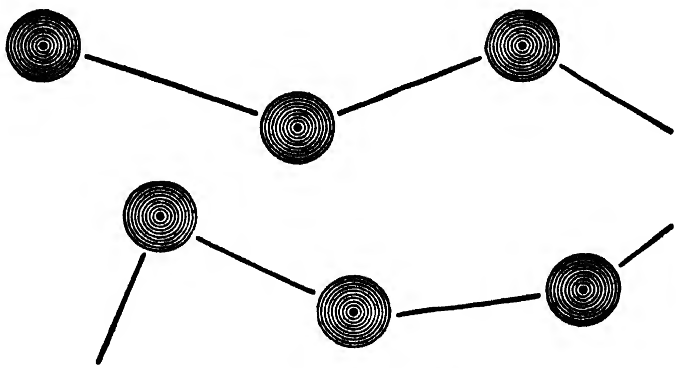


FIGURE 49. *Aiming Test*

(After Muscio)

the results for six different rates in the aiming test for six subjects. Each number in the table was obtained by adding together the distance of 180 shots, each scored to the nearest half mm. from the circumference of the bull's eye; these 180 shots (at each rate) being distributed over six sittings as shown in Table 47.

TABLE 47[51]

RATES (METRONOME)	AVERAGE
60	176.8
90	180.3
120	223.3
150	301.3
180	413.1
210	506.1

Note:—It is important to note that high score indicates decreased accuracy.

(After Muscio)

[51] *Ibid.*, p. 20.

The Pendulum test, involving a complicated procedure of retrieving water from a pendulum in motion, duplicating that used by Miles,[52] was tried on only one subject.

The findings of the study show that: [53]

(1) An increase in rate of movement (for certain rates used) causes an increase in the inaccuracy of movement. The faster the rate of work at any time, the greater, in general, is the increase in inaccuracy produced by any unit increase in rate;

(2) Continuous work for several hours with tests of motor precision fails to show a gradual increase in inaccuracy, but the very reverse. The resulting inaccuracy curve under these conditions is almost the exact opposite of the typical industrial accident curve for the morning hours.

(3) A curve for inaccuracy of movement, broadly similar to the typical industrial accident curve for the morning hours, can be experimentally obtained by gradually increasing the rate of movement in a morning period of continuous work with motor precision tests.

In the opinion of Muscio, "in view of what is known concerning hourly variations in speed of producton, the conclusion suggested by these results is that the principal factor in the hourly variations in the number of industrial accidents is *not* fatigue *but rate of work*. There *may* be hours of the work-day for which this conclusion is not true, and the question whether this is so or not is highly important; but the conclusion seems true for the morning hours at least."

However, recent studies by Windmoeller [54] have shown, for example, that the relationship between speed and accuracy varies definitely with the character of the work, with the subjects employed, and with the conditions under which the work is done. The complexity of the problem and of the variables involved point to the need of more extensive investigation in which results can be obtained for more subjects, working for longer periods of time, with a greater diversity of operations. No definite conclusions concerning the relative importance of fatigue and rate of work can be drawn until both the character of fatigue itself and the effect of variations in rate and accuracy under diverse conditions have been more definitely established.

3—Atmospheric Conditions

Accident liability appears to be affected, among other factors, by *atmospheric conditions*. Thermographic records, obtained for a period of approximately ten months in three munition plants, were compared by Osborne and Vernon [55] with the number of cuts treated in the

[52] W. R. Miles, *Psychological Review*, 27 (1920), pp. 361–367.

[53] "Two Contributions to the Study of Accident Causation," *Ind. Fat. Res. Brd. Rep.* No. 19, p. 36.

[54] O. Windmoeller, "Die Beziehungen zwischen Arbeitsschnelligkeit und Arbeitsgute," *Psychot. Z.*, 5 (1930), pp. 1–13; 65–78.

[55] E. E. Osborne and H. M. Vernon, *op. cit.*

plant dispensary. The results obtained are shown in Figure 50. Accidents are found to be at a minimum at 67.5° F. At 52° there is an increase of approximately 35 per cent in accidents for both men and women. At above 67.5° accidents rise for both men and women, and

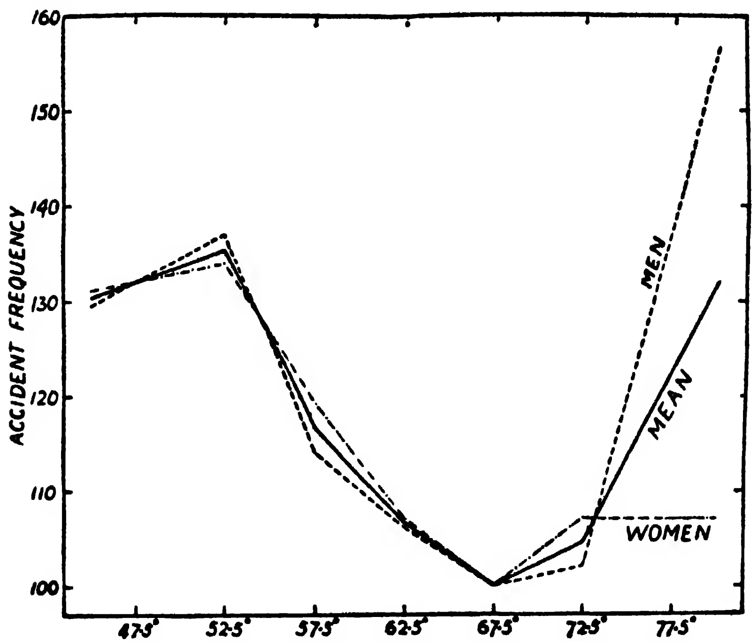


FIGURE 50. *Accident Frequency in Relation to Temperature (After Osborne and Vernon)*

at 72.5° accidents increase rapidly for men and to a very small extent for women. Taking into consideration other studies on optimal temperature for sedentary and active, light and heavy occupations,[56] the investigators suggest 62.5° as the temperature for machine work which will give the greatest production combined with least increase in accidents above the minimum found at 67.5°.

Data obtained by Vernon and Bedford,[57] in a study of 2,459 accidents incurred by 2,963 coal miners between 1920 and 1925, supports the view that atmospheric conditions, more particularly the cooling

[56] W. D. Hambly and T. Bedford, "Preliminary Notes on Atmospheric Conditions in Boot and Shoe Factories," *Ind. Fat. Res. Brd. Rep.*, No. 11 (1921), pp. 69; H. M. Vernon and T. Bedford, "Two Investigations in Potters' Shops," *Ind. Fat. Res. Brd. Rep.*, No. 18 (1922), pp. 74.

[57] H. M. Vernon and T. Bedford, "The Relation of Atmospheric Conditions to the Working Capacity and the Accident Rate of Coal Miners," *Ind. Fat. Res. Brd. Rep.*, No. 39 (1927), pp. 33.

power of the air as measured by the *kata-thermometer,* influence accident rate. In one colliery the accident rate of three seams where the wet kata cooling power was 15.2, 11.3, and 10.2, the accident severity [58] rate of colliers and trammers was 3.2, 4.8, and 4.9, respectively. The accident rate at a colliery where ventilation in the airway was worse than in another, exceeded the accident rate of the latter by 55 per cent.

Confirmatory evidence on the relation between accidents and atmospheric conditions in coal mines has been obtained in two additional studies by the Industrial Health Research Board investigators.

TABLE 48

Accident Rates in Relation to Dry Bulb Temperature

TEMPERATURE RANGE	MEAN TEMPERATURE	ACCIDENT FREQUENCY PER 100,000 MAN SHIFTS		ACCIDENT SEVERITY (DAYS LOST PER 1,000 HOURS WORKED)		DAYS LOST PER ACCIDENT	
		1924–5	1927–8	1924–5	1927–8	1924–5	1927–8
Coal Face Workers							
Under 70°	63.9°	104	133	3.5	4.4	33	33
70° to 79°	77.3	144	144	3.6	3.8	25	26
80° or more	82.8	184	173	4.5	4.8	24	28
Others Underground							
Under 70°	62.0	58	57	1.84	1.79	32	31
70° to 74°	72.7	87	81	2.41	2.45	28	30
75° or more....	78.5	100	92	2.29	2.63	23	29

(After Vernon and Bedford)

These studies [59] deal with miners working underground and with surface men whose records were first studied for the years 1924–25 and later for the years 1927–28. The first study included 18,455 underground men and 4,456 surface men working in ten collieries all situated within ten miles of one another, whose records were studied for the period 1924–25. Disputes in 1926 ended with a reduction in wages, increase in working hours underground, the erection of pithead baths, etc. The records of 10,000 underground men and 2,700 surface men in eight of the same collieries for the years 1927–28 were analyzed to observe the effects of these changes on absenteeism, accidents, etc.

The data on temperature obtained in the two independent studies

[58] Severity was calculated in terms of days lost per 1,000 hour shifts, assuming a 7½ hour shift and with a maximum loss of 150 days for serious and fatal accidents.

[59] H. M. Vernon and T. Bedford, "A Study of Absenteeism in a Group of Ten Collieries," *Ind. Fat. Res. Brd. Rep.,* No. 51, (1928), pp. 62; H. M. Vernon and T. Bedford, "The Absenteeism of Miners in Relation to Short Time and Other Conditions," *Ind. Health Res. Brd. Rep.,* No. 62 (1931), pp. 1–34.

is summarized in Table 48. Both studies agree in showing an increased frequency of accidents associated with a rise in underground temperature. Supplementary data shows that the increase affects mainly minor accidents, those entailing less than ten days disablement being three times more numerous at an underground temperature of 81° than at 63°. Major accidents, causing 60 or more days disability, were found to be less numerous at high than at low temperatures.

TABLE 49

Accident Frequency of Coal Face Workers in Relation to Age and Temperature

AGE GROUP	ACCIDENTS PER 1,000 MEN PER YEAR AT			RELATIVE ACCIDENT FREQUENCY AT			
	UNDER 70°	70° TO 79°	80° OR MORE	UNDER 70°	70° TO 79°	80° OR MORE	TEMPS. ABOVE 70°
Under 30 years	203	263	289	109	120	115	117.5
30 to 39 years	186	219	251	100	100	100	100
40 to 49 years	180	232	299	97	106	119	112.5
50 or more years	191	331	344	103	151	137	144

(After Vernon and Bedford)

An interesting feature of these studies is the analysis of the influence of *age* on accidents in relation to *atmospheric conditions* and *fatigue*. The studies agree in finding an excess of accidents on the part of younger men as compared with those of medium age, largely due to inexperience. The older men are more skillful and careful, but they appear to tire easily, and this fatigue effect is reflected in an increased number of accidents. The findings with respect to the three factors in the case of coal face workers are summarized in Table 49. If the frequency of accidents shown by men aged 30 to 39 when working at various temperatures is taken as 100 in each case, it is evident that the frequency of accidents of men over 50 working at high temperatures shows a striking rise. The fatigue effect of high temperatures explains, according to the investigators, the increase of accident rates with age and experience observed in coal mining. In another section of their analysis the observers found that men who incurred minor accidents at high temperatures claimed accident compensation three or four times more frequently than those sustaining accidents at low temperatures. This may be associated with the disinclination to work under unpleasant and fatiguing conditions and may also account for the apparent excess of accidents in the older men at higher temperatures.

The probability that a substantial part of lost time due to accidents

is avoidable is made evident in a parallel study in one of seven Scotch collieries,[60] where the frequency of accidents entailing absences of under 60 days was reduced, in one year, by 42–43 per cent, and longer accidents by 79 per cent, as a result of pressure brought to bear upon the men by the management.

4—Illumination

Among other factors affecting accident liability is ***illumination***. According to Stephenson[61] the inferior illumination of artificial light, as compared with daylight, is accompanied by an increase in accident frequency. As evidence he cites findings from a study showing that more than twice as many accidents occur in the two winter quarters of the year for the part of the day when artificial illumination was used, as for the corresponding part of the day in the two summer quarters of the same year.

The influence of this, as of other factors in both "accident-proneness" and in "accident liability," will bear much more extensive investigation. Scattered results on various aspects of the problem of reducing accidents are available. On many important questions little or no light has been shed. It is only necessary, for example, to consider the inadequacy of the evidence on the relation between minor and major accidents in the industrial plant to recognize the vast amount of work which remains to be done in this field. Certain very definite results have been accomplished through the application of psychological methods in the study of industrial accidents. Perhaps the most important of these is the change which it has brought in the underlying philosophy of accident prevention—the substitution of a principle of "causation" for the earlier philosophy of "fault"[62]—the replacement of a fatalistic doctrine of "chance" by a dynamic policy of individual hygiene in accident prevention. The exact character of this policy, and the procedures adopted in its administration will appear in the consideration, in the next chapter, of accidents in the transportation industry.

[60] T. Bedford and C. G. Warner, "A Study of Absenteeism at Certain Scotch Collieries,' *Ind. Health Res. Brd. Rep.*, No. 62 (1931), pp. 46.
[61] A. Stephenson, *op. cit.*, p. 196.
[62] J. H. S. Bossard, *op. cit.*, pp. 418–19.

XVIII. ACCIDENTS IN THE TRANSPORTATION INDUSTRY

The psychological approach in the prevention of accidents has found its widest application in the transportation industry.

According to a report of the National Safety Council [1] accidents involving motor vehicles resulted in 33,000 deaths in the United States in 1930. Approximately 27 out of every 100,000 people in the United States are killed annually by motor vehicles. With an observed ratio of about 35 non-fatal injuries to each fatality in cities and states obtaining accurate information, it can be said that there are 1,000,000 non-fatal motor vehicle injuries each year. Accepting as a basis the figures of the First National Conference on Street and Highway Safety,[2] the probable cost, conservatively estimated, of motor vehicle accidents in 1930 is close to $1,000,000,000.

The total number of fatalities from causes other than motor vehicles is decreasing from year to year, while those due to automobiles, responsible for the vast majority of deaths in this group, are increasing so rapidly that, if the present rates of change persist, by approximately 1940 more people will be killed by automobiles than by all other accidental causes of death.[3] The death rate by automobiles in 1929 was ten times that of 1911. The fact that this is not solely the result of an increase in the number of vehicles is indicated in the consistent rise, since 1926, of the number of deaths per 100,000 automobiles from 95.2 to 115.0. This increase has occurred in spite of the tremendous improvements, in recent years, in the construction of the car itself and more particularly of the mechanical accessories, such as tires, brakes, lights, etc. which make for safety in car operation. The record has become worse in spite of increasingly stringent state requirements for periodic inspection, and of the tremendous emphasis by civic organizations on the maintenance of cars for safety purposes. The automobile itself has been so perfected that, according to the reports of state motor vehicle departments, mechanical defects are responsible for less than one accident in twenty. The aetual percentage of accidents due to such causes, in 1928, in three states are as follows: [4]

[1] *Accident Facts*, 1931, Chicago, p. 19.
[2] *Report of the National Conference on Street and Highway Safety*, Washington, 1926.
[3] A. P. Weiss and A. R. Lauer, *Psychological Principles in Automotive Driving*, Columbus, Ohio, 1930, p. 2.
[4] *Ibid.*, p. 2.

Massachusetts	4.97
Connecticut	4.56
Rhode Island	1.28
Average	3.61

It is evident, from these figures, that automobiles are generally more dependable than the men or women who drive them. This may result, as Ach [5] suggests, from an *inherent* conflict between the usual speed of operation of motor vehicles and the psychophysical capacity for response at these high speeds. Whatever the cause, the fact that the personal element is the most important in motor vehicle accidents is beyond question.

The problem of motor vehicle accidents is of utmost concern to the public at large. It concerns the individual who without any contributory negligence on his part may become involved in an accident. It is a source of worry to parents whose children, forced to play in public streets, pay with lives and maimed bodies for any failure to give adequate consideration to the mental characteristics of those who drive motor vehicles. The rate structure and policies of insurance companies are tremendously affected by the incidence of such accidents. These present a problem of "hygiene" as complex and as urgent as any faced by municipal, state, and Federal departments responsible for the maintenance of public welfare.

VEHICULAR ACCIDENTS IN INDUSTRY

In addition to being a problem of general public concern, the prevention of motor vehicle accidents is a specific problem in industry. It is of great moment to industrial firms which make use of large fleets of motor vehicles for delivery and other purposes. It is of major importance in the transportation industry, whose sole functions are the *efficient* and *safe* operation of motor vehicles. The position occupied by accidents in the economy of the transportation industry is evident in the electric railway industry. Annual reports in this industry have shown that year after year 3, 4, 6, 8, and even 10 per cent of operating revenue is spent on accident claims.[6] In the case of one company, the Boston Elevated Railway, the charges to operating costs for injuries and damages amounted to $1,502,313.56 in 1928 and to $1,201,642.83, in 1929.[7]

According to estimates prepared by the National Association of

[5] N. Ach, "Psychologie und Technik bei Bekampfung von Auto Unfällen," *Ind. Psychot.*, 6 (1929), pp. 87–97.

[6] *Safe Transportation*, Personnel Research Federation, New York, 1930, p. 5.

[7] *Ibid*, p. 4.

Taxicab Owners [8] 80,000 of the 26,501,443 automobiles registered in the United States are taxicabs. The annual taxicab mileage is estimated at 2,200,000,000 miles, approximately one per cent of the total motor vehicle mileage of the country. The average cost for accidents in this industry alone is close to one cent per mile, or close to $22,000,000.00 per year.[9]

The enormous cost of accidents to the transportation industry is largely responsible for the initiative which has been taken by this industry in applying psychological methods in the reduction of accidents. The manufacturing industries have largely contented themselves with the traditional methods of the safety engineer. A number of progressive companies operating street railways, motor busses, and taxicabs have supplemented these by a scientific analysis of personal factors in accident, and by psychological techniques for detecting and rehabilitating accident-prone operators of motor vehicles. Certain of these techniques, as applied in selection, have been described in an earlier chapter. The remaining section of this chapter will be given over to the discussion of methods applied (a) in the analysis of the nature of accident-proneness in motor vehicle operation, and (b) in the individualized treatment of motor vehicle operators involved in multiple accidents.

Before proceeding with this discussion it may be well to point out the distinction between the term accident as used in the present and in preceding chapters. The effects of accidents in the transportation industry are not confined to employees alone. Injury to passengers and to pedestrians, and damage to public and private property represent the most important phases of accidents in motor vehicle operation. As a matter of fact, in a serious and costly accident, the operator of the public vehicle may himself suffer no injury and his vehicle may remain undamaged. In a sense, the accident in the transportation industry is a measure of proficiency on the job in the same sense as production and spoiled work in the manufacturing industry are measures of industrial proficiency. At the same time, the objective circumstances and the surrounding personal conditions of the transportation accident resemble closely those which are found in cases of injury to the worker in the industrial plant. In the operation of motor vehicles the number of accidents is not only an indication of a worker's operating efficiency, but also reflects the extent of susceptibility of the operator to accidents. There is good reason to believe that the incidence of accidents in the transportation industry is determined by the same factors and governed by the same laws which account for personal injuries in the manufacturing plant.

[8] *Preventing Taxicab Accidents,* Metropolitan Life Insurance Co., New York, 1931, p. 5.
[9] Estimate by the author on the basis of accident experience of companies operating in ten cities.

ACCIDENT-PRONENESS IN THE TRANSPORTATION INDUSTRY

In the transportation industry, as in manufacturing plants, accidents do not distribute themselves by chance. Operating under identical conditions, a small percentage tends to be involved in many accidents while a large proportion of the working force remains relatively free from accident. The incidence of accident-proneness in the operation of motor vehicles has been well demonstrated in a recent study in the taxicab industry. A total of 1871 accident reports covering 1294 drivers employed by a group of companies were analysed with respect to the accident frequency per man.[10] The results of this analysis are shown in Figure 51.

For purposes of comparison, the entire group of workers has been sub-divided into ten equal groups. The proportion of the total number of accidents for which each of these groups is responsible is shown in the cross-hatched rectangles on this figure. The figures placed within the hatched area represent the percentage of total accidents for which the group has been responsible. So for example, the figure shows that the 10 per cent of employees with the worst accident record have been responsible for 31.85 per cent of all the accidents sustained by the 1294 taxicab drivers included in the study. It can be seen from the figure that one-third of the taxicab drivers have been responsible for 69.3 per cent of all the accidents. Fifty per cent of the drivers have been responsible for 82.84 per cent of the accidents, whereas the remaining 50 per cent account for only 17.16 per cent of all the accidents. A further analysis of the figure shows that 25.2 per cent of employees have been entirely free from accidents in the period covered by this report. It is interesting to note that the data obtained in accident-prone studies in other types of industries, if plotted on Figure 51, would closely conform to the curve shown on this figure.

Studies in the electric railway industry have revealed a similar distribution of accidents among employees. The Personnel Research Federation [11] has obtained accident data of approximately 100 typical employees of each of 32 street railway companies. The summary of the replies received on the accident history of 3290 operators is shown in Table 50. It can be seen that 2001, or 61 per cent, of the operators had five or fewer collisions. The remaining 1289, or 39 per cent, had more than five collisions each. The first group had a total of 5407 accidents or an average of 2.7 per man, while the latter group was involved in 11,567 accidents, or an average of 9 accidents each.

The extent of difference in number of accidents between two groups employed for the same period of time can be further illustrated from an unpublished study of motormen made by the author [12] in 1927.

[10] *Preventing Taxicab Accidents, op. cit.*, p. 21.
[11] *Safe Transportation, op. cit.*, p. 7.
[12] M. S. Viteles, from a report prepared for Philadelphia Rapid Transit Co., May 26, 1927.

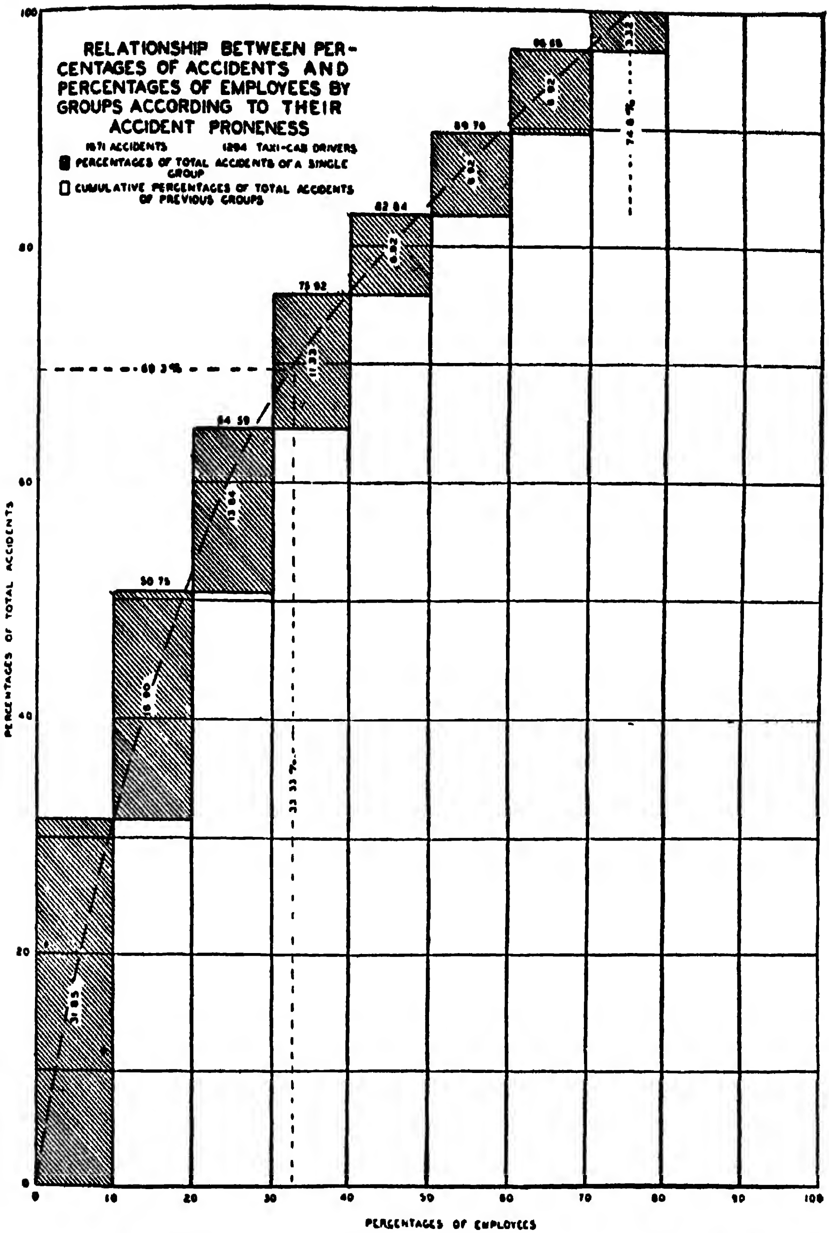


FIGURE 51

(*From* Preventing Taxicab Accidents, *Metropolitan Life Insurance Co., New York, 1931*)

In this investigation, the Transportation Department of the Philadelphia Rapid Transit Company submitted the names of 100 trainmen with exceptionally good accident records, and of 100 trainmen with exceptionally bad accident records. The names of trainmen with more than fifteen years of service were set aside. The remaining trainmen, were paired so as to leave in both groups exactly the same number of trainmen with the same length of service. It was possible to

TABLE 50

Accident Data of 3290 operators employed by 32 Street Railway Companies [13]

NUMBER OF MEN	NUMBER OF COLLISION ACCIDENTS PER MAN DURING THE YEAR 1927
911	0, 1, or 2 collision accidents
1090	3, 4, or 5 collision accidents
703	6, 7, or 8 collision accidents
372	9, 10, or 11 collision accidents
134	12, 13, or 14 collision accidents
80	More than 14 collision accidents

obtain fifty-four such pairs distributed as follows with reference to length of service:

	NUMBER	LENGTH OF SERVICE
	19	1–2 years
	7	3–4 "
	4	5–6 "
	6	7–8 "
	13	9–10 "
	5	11 years and above
Total	54	

An analysis of the accident records revealed that the 54 men in the *Good Record* group had been involved in a total of *57* accidents. The 54 men in the *Bad Record* group had sustained a total of *784* accidents, about 14 times as many as those occurring in the *Good Record* group. The distribution of these accidents is shown in Table 51.

A study by Slocombe and Bingham,[14] on the property of the Boston Elevated Company, reveals the same differentiation among operators with respect to accidents. A canvass of records showed that half of the accidents happened to less than one-third of the operators em-

[13] *Safe Transportation, op. cit.*, p. 7.
[14] S. Slocombe and W. V. Bingham, "Men Who Have Accidents," *Pers. J.* (1927), p. 2.

ployed by this company. In one sample of 200 men, half the accidents happened to only one-fifth of the motormen. Of 2,300 men employed in the operation of surface cars 1,828 had 3,870 collisions or an average of 2.1 per man whereas 472 high-accident men had 3,327 or an average of 7 collisions per man.[15]

The existence of susceptibility of accidents in motor vehicle operation has been demonstrated not only within the transportation industry, but in studies of the operators of private automobiles. A study by the National Safety Council[16] of 64,000 New York State motor vehicle accidents showed that the number of drivers with 3 accidents was approximately 3 times the number that could be expected on the basis of a chance distribution. In another investigation,[17] the records of 100 drivers involved in fatalities were compared with the records of 100 drivers chosen at random from the files of one of the State Motor Vehicle Bureaus. In the random group of drivers, one out of every 20 had had a bad record the previous year. In a group of drivers involved in fatalities, 7 times as many had bad records the previous year.

TABLE 51

Distribution of Accidents of 108 Motormen Paired for Length of Service

TYPE OF ACCIDENTS	GOOD RECORD (54 Motormen)	BAD RECORD (54 Motormen)
Vehicles	7	136
Autos	34	511
Personal	0	27
Car	16	110
Total	57	784

(After Viteles)

It is clearly obvious from the studies cited above that in the transportation industry, as in other industries, the occurrence of accidents depends largely upon individual susceptibility. Here, as elsewhere, they happen frequently to some men and infrequently to others as a logical result of a combination of circumstances, the nature of which can only be made clear by experimental analysis.

The history of accident prevention in the transportation industry resembles closely that of other industries. Propaganda and mass education have been followed by statistical studies designed to determine

[15] C. S. Slocombe and E. E. Brakeman, "Psychological Tests and Accident-Proneness," *Brit. J. Psych.*, 21 (1930), p. 37.

[16] A. P. Weiss and A. R. Lauer, *op. cit.*, p. 3.

[17] W. V. Bingham, "Prone-to-Accident Driver," *Proceedings 17th Annual Conference on Highway Engineering*, Ann Arbor, Mich., 1931, p. 4.

the influence, upon accident-proneness, of such factors as age, physical condition, experience, individual mental traits, etc. In addition, in the transportation industry, the statistical analysis of mass data has been supplemented by another psychological procedure—*the clinical study of the individual involved in accidents* as a means of determining the exact factors operating in *his* case and as an aid in the prevention of further accidents on *his* part.

THE CLINICAL METHOD IN ACCIDENT PREVENTION

The psychological study of accidents in the manufacturing industry has been largely confined to a statistical study of factors influencing accident susceptibility. Such statistical studies [18] are of unquestionable significance in arriving at a knowledge of the causes of accidents, and in the development of a program for reducing accidents in industry. However, they suffer from serious limitations as practical aids in the reduction of accidents.

In the first place the statistical approach is oriented from the viewpoint of discovering relations existing in a group of individuals, and not from the point of view of the adjustment of the single individual who has become involved in or is susceptible to accidents. It contributes little in the way of techniques or methods which may be useful in the adjustment of the individual worker who sustains accidents. The discovery, for example, that the proportion of younger men involved in accidents is greater than that of older men; [19] that there is a correlation between minor illnesses and minor accidents; [20] that there is a difference of 48 per cent in accident rate between those scoring above and those scoring below the average on tests of psychomotor and other traits; [21] etc., is of extremely great interest and importance. However, such facts are insufficient, in themselves, in helping one who has already become involved in an accident and in preventing further accidents on his part. The statistical approach limits itself to the accumulation of facts, but provides no procedure for applying these facts in the further study and adjustment of the individual worker.

The function of the statistical approach and of statistical investigations in preventing accidents attributable to the human factor may be described as that of investigating *group* tendencies. In contrast with this is the *clinical approach*—the functions of which are to determine the relationship existing among a number of factors which have played or may play a part in the case of the individual who becomes

[18] M. S. Viteles, "The Clinical Method in Industry," *Ind. Psych.*, 1 (1926), pp. 753–58; M. S. Viteles, "The Clinical Viewpoint in Accident Prevention," *Proceedings 5th International Congress of Psycho-technology*, Utrecht, (1928).

[19] H. M. Newbold, *op. cit.*

[20] *Ibid.*

[21] E. Farmer and E. G. Chambers, *op. cit.*

involved in accidents and to develop a program for the prevention of additional accidents on his part.

Another limitation of the statistical viewpoint in accident prevention is its emphasis upon isolated aspects of individual personality, in contrast with the concern, in the clinical approach, for the *total personality* of the accident-prone individual. The point of orientation, in the statistical analysis, is not the individual who, in the final analysis, is the one susceptible to and suffering from accidents, but isolated sectors of individual make-up such as age, experience, reaction time, perseveration, accuracy of response, etc. It is assumed that the individual is a sort of mosaic, and that the sum of the single stones in this mosaic constitutes the whole.[22] It is undoubtedly true that a detailed examination of each stone tells much about the *structure* of a mosaic, but the contribution of each to the value of the whole flows from the *integration* of the various parts, and can only be fully determined through an examination of the whole and of the interrelationships among the parts in the whole.

The aim of the clinical approach is to examine the whole individual, and from an examination of the whole to arrive at a knowledge of the significance of the various aspects of his personality—the relative importance of each sector of his personality in a given situation. The application of the clinical approach in the analysis of accident causes involves a complete study of the individual involved in accidents. As indicated in the discusson of the clinical method in the chapter on "Psychological Foundations of Industrial Psychology," it makes the individual the point of departure, and provides for a thorough examination of every factor—physical, mental, social, and economic, and of those extraneous to the individual—which may have played a part in the accident in which he has been involved. From such a clinical analysis it is possible not only to assemble complete data on the causes of the accident, and to provide for the adjustment of the individual, but also to arrive at sound principles for the prevention of accidents in industry.

CLINICAL STUDIES OF ACCIDENT-PRONE DRIVERS IN THE TRANSPORTATION INDUSTRY

In the transportation industry there is an increasing tendency to view the occurrence of accidents as an individual problem. "Just as a physician diagnoses and treats a chronic ailment to effect a cure, so those employees who are repeatedly involved in accidents or are *accident-prone* are being studied and treated individually in the belief that many of them may be adjusted properly and become assets rather than liabilities. Case study methods, while reducing accident

[22] M. S. Viteles, "Die 'Gestalt' Betrachtungsweise in der angewandten Psychologie," *Z. für Ang. Psy.*, 35 (1930), pp. 525–31.

frequency among the small group of high-accident men, tend at the same time to encourage the entire group of employees to improve their records by breaking down the age worn theory that accidents are a matter of 'hard luck' and that they cannot be prevented." [23]

The diagnosis of accident-proneness is being followed by specialized treatment and treatment based on an exact knowledge of the factors which are responsible for the accident record in the case of the particular individual.[24] Treatment takes the form, not of mass education, or the more drastic measure of termination, but most frequently that of systematic instruction designed to efface such faulty habits of operation as may be responsible for the accident record. In other cases, medical treatment, discipline, encouragement, and supervisory follow-up may be employed in rehabilitating the accident-prone employee. This treatment is differential in character. It recognizes that there are many different causes of accidents and that they may be combined in different patterns in different individuals.

The knowledge of the factors which play a part in the case of a single individual is obtained by an experimental study of the individual. This includes psychological examination, close observation of operation details, a review of his relationship with supervisory officers and fellow-workers, and possibly a detailed study of the home circumstances.

On the basis of these facts, the program most suitable for that individual is laid out. In some cases, the causes for the bad accident record cannot be eradicated and, in these instances, discharge or transfer must be resorted to as a means of preventing further accidents on the part of such an operator. Perhaps, however, the most significant of the very many findings obtained from such an approach is the fact that termination or transfer need be resorted to in relatively few cases. So, for example, in the case of 54 men studied in one accident clinic, in a period of a year, only 3 men were recommended for discharge.[25] The point of view of the accident clinic is that the dismissal [26] or even transfer of a so-called "accident-repeater" can be justified economically and socially only when it has been fully and reliably determined that it is impossible to correct the individual characteristics and habits which make him accident-prone.

Where selection tests are being used a large proportion of those who are fundamentally unsuited for motor vehicle operation are being refused employment. The selective process of work itself results in the elimination of others who are totally unsuited for this work. Those who remain tend to be a somewhat selected group whose acci-

[23] *The Accident-Prone Employee,* Metropolitan Life Insurance Co., New York, 1931, p. 6.

[24] W. V. Bingham, "The Prone-to-Accident Driver," *Proceedings 17th Annual Conference on Highway Engineering,* Ann Arbor, 1931, p. 9.

[25] S. M. Shellow, "The Accident Clinic, How it Functions and What it Accomplishes," *Pers. J.,* 3 (1930), p. 214.

[26] *Preventing Taxicab Accidents, op. cit.,* p. 27.

dent record is largely due to factors other than native capacity, such as faulty habits of operation, faulty attitudes, medical defects, etc., subject to correction when their exact nature is uncovered.

Study of Accident-Prone Motormen—Cleveland Railway Company

Street railway companies in Milwaukee, Cleveland, Boston, and taxicab companies in Philadelphia and New York have made use of clinical studies of accident-prone drivers as an aid in the reduction of accidents. The methods employed and results obtained in this approach can, perhaps, best be illustrated by a brief description of the procedures and findings in the study of accident-prone drivers by the Cleveland Railway Company.[27] Notwithstanding a 22.3 per cent reduction in accidents over a five year period, following the application of the traditional methods of safety engineering, there were indications that general educational safety work failed to accomplish results under certain conditions. This appeared particularly in the case of the *Woodhill Station,* which experienced a steady increase in accidents in 1927 as compared with other divisions. This was made an experimental station for the application of the methods of clinical psychology as an aid in accident reduction.

One hundred and sixty-seven motormen employed in this station were found to have 0.86 accident per thousand car miles during 1928. Fifty motormen with the poorest records per thousand car miles were considered as accident-prone for the purposes of the study. This selected group of men, comprising approximately 30 per cent of the total number of motormen at the station, had been involved in 44 per cent of all the accidents reported at the station.

As a preliminary to the individual study of each man, an analysis was made of the past service records in order to determine the relationship between age, experience, delinquencies, and similar factors and involvement in accident. Following this, a careful clinical study was made of each motorman. The motormen were frankly informed of the purposes of this study in an announcement stressing its constructive aim in helping to improve the performance of each man and the standing of the station. The case study of each accident-prone motorman included a consideration of the following items:

1. *Observation of operations,* involving a careful examination under normal operating conditions of
    a. *General operation*
    b. *Motoring habits*
    c. *Mental factors*
    d. *Physical factors.*
2. *Analysis of previous and current year's accident record.*
3. *Personal interview.*
4. *Decision as to primary causes of accident-proneness.*

[27] *The Accident-Prone Employee, op. cit.*

5. *Preparation of report of case recommending treatment based upon findings.*

6. *Treatment and follow-up.*

The exhaustive and analytical character of the study of each operator is illustrated in the complete report on Case # 28.

CASE NO. 28

Badge No. 7–513

In Service—2 Yrs., 2 Mos. Age—29

I—ACCIDENT DATA:

(a)	Total Accidents, 1928		32
(b)	Accidents per 1,000 Car Miles, 1928		1.21
(c)	Total Accidents, 1929		7 (To Date)
(d)	Accidents for which he was disciplined, 1928		2
(e)	Major Types of Accident, 1928:		
	1. Vehicle Collisions		12
	Vehicles Striking Rear End	5	
	Vehicles Cutting onto Track	3	
	Side-Rubs	2	
	Miscellaneous	2	
	2. Boarding		5
	3. Falls in Car		5
	4. Alighting		1
	5. Miscellaneous		9

II—SERVICE DATA:

(a)	Misses, 1927	3
	Misses, 1928	1
(b)	Reprimands, 1927	1
	Reprimands, 1928	2
(c)	Number of Days of Discipline, 1927	4
	Number of Days of Discipline, 1928	2
(d)	Power Consumption Rating	+ .01 K.W.H./C.M.

III—OBSERVATION OF OPERATION: (Two Observations)

This motorman gives one the impression of being a conscientious worker; he attends strictly to business and seems to be alert constantly. When he is carrying a heavy load he puts all of his effort on the job, as though determined to do his utmost to get over the road on time.

The subject clearly displays impulsive characteristics; he wants to keep going and is impatient to get off after making a stop. His stops and starts are much too fast, causing a standing load to lose its balance. Moreover, he frequently fails to close his door before starting. Twice within a few days he was observed starting his car while a passenger was still on the step. He has also formed a habit of opening his door before bringing the car to a stop.

Attention, judgment of speed and distance, reaction and attitude appear to be beyond reproach. The causative factors of accidents in this case are almost

solely faulty starting and stopping habits. This is substantiated by the fact that 35% of all his accidents are falls, boarding, in car, and alighting. Moreover, five of the twelve vehicle collisions in which he became involved during 1928 are "vehicle striking the rear of car," also attributable to sudden stops.

IV—Personal Interview:

The subject is somewhat nervously constructed; his speech is rapid and his gestures and movements are impulsive at times. As observations of his work disclosed, he is inclined to be impatient; to make hasty decisions and then later to regret having made them. His attitude toward his work is excellent. He appears conscientious and is determined to make good. He seemed very much concerned about his high accident record, stating that he was glad to know all the facts and that he would do his best to correct the starting and stopping habits he had formed, none of which he denied.

Mentality, health and family conditions are normal in every respect.

V—Treatment:

That he be reinstructed weekly on the platform, and that his case be reviewed within two months' time.

The most significant finding in the Cleveland study is that in no two cases were the causes of accident-proneness exactly similar. "In most instances, several causes existed, although in each case, one of these was found to be of primary importance." [28] The percentage distribution of primary causes of accident-proneness among the 50 men is presented graphically in Figure 52.

An analysis of these various causes [29] shows that physical difficulties were found to be of primary importance in only 12 per cent of the cases, classified in Figure 52 under the headings of "Defective Vision," "Organic Diseases," "High Blood Pressure," and "Senility." This is particularly significant in view of the tendency of industrial medical men to place the responsibility of any maladjustment in industry largely upon physical difficulties. In 22 per cent of the cases an improper "mental attitude," or "personality maladjustment," was found to be the primary factor in accidents. The largest group of accident-prone men included those whose accident records were due primarily to "operating defects," 66 per cent of the men exhibiting "failure to recognize potential hazards," "faulty judgment of speed and distance," "improper distribution of attention," etc.

The procedure adopted in each case for preventing further accidents depended upon the analysis of the accident-prone drivers' particular defects. In certain cases, medical treatment was undertaken. In others, with the co-operation of the Supervisory Force of the Operating Department, a program was outlined to overcome the personality defects. Where faulty habits of operation were at the basis of the bad accident record, reinstruction was undertaken. A special instructor rode periodically with the subject while on duty and tactfully and

[28] *Ibid.* p. 10

[29] *Ibid.* p. 15.

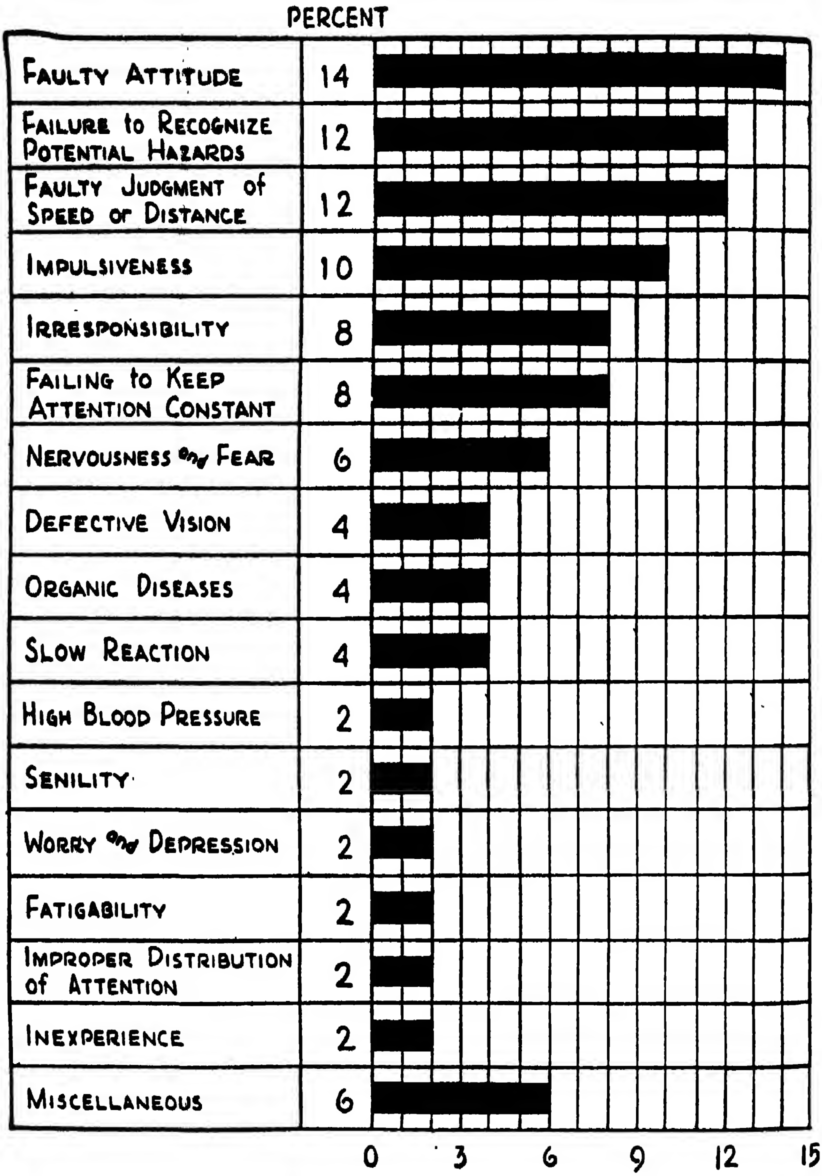


FIGURE 52. *Primary Causes of Accident-Proneness: Percentage Distribution Among Fifty Motormen, Woodhill Division, The Cleveland Railway Company*

(*From The Accident-Prone Employee, The Metropolitan Life Insurance Company, New York, 1930*)

carefully induced the substitution of proper habits of operation for faulty operating habits.

As a result of this application[80] of the clinical method in the study and treatment of accident-prone drivers, the combined rate of accidents on the part of the motormen[81] involved in this study dropped from 1.31 per thousand miles in 1928 to 0.75 in 1929, equivalent to a reduction of 42.7 per cent. The accident records of accident-prone motormen before and following study are shown in Figure 53. All but three individuals show a reduction in accident rate and in two of these cases treatment was postponed indefinitely because of company policy. When it is recognized that these are the men with the worst accident records who, under ordinary conditions, are simply terminated, or held on without treatment, because of length of service, the significance of these results gather additional import.

In addition to the improvement of the individual motormen, the Woodhill Station showed the largest accident reduction on the system for the period of the study in contrast to the steady increase in record in 1928 and 1927 over 1927 and 1926, respectively. The satisfactory results of this program have led to its extension to other stations and to the other classes of employees of the Cleveland Railway Company.

Other Studies of Accident-Prone Operators of Motor Vehicles

The procedures employed in the study of accident-prone drivers by the Cleveland Railway Company are essentially the same as those which have been used informally for many years by the Psychological Division of The Milwaukee Railway and Light Co., established in 1920 by the author in co-operation with Arthur J. Rowland, Educational Director of the Company. In January, 1929, a formal *accident clinic* was organized by this company, under the direction of S. M. Shellow,[82] who is at present psychologist for this organization. The membership of this clinic includes a Superintendent of Transportation, the Safety Director, Medical Director, Head of the Claims Department, divisional superintendents interested in particular cases, Superintendent of Training, a representative from the employees' association, Psychologist, and Assistant Psychologist.

The records of men selected by the Safety Director, because of the frequent occurrence of accidents, or because of some specific accident, are reviewed at the bi-weekly meetings of this group. The records of such men are thoroughly reviewed and summarized by the psychologist who also applies the motorman selection test and other tests described in Chapter XIV, as an aid in analyzing the causes of accident-proneness. Each member of the clinic presents the information about

[80] *Ibid.* p. 20.

[81] Actual number reduced to 44 as a result of transfer occurring within the period of study (3 men); sickness (1 man); resignation and discharge (2 men).

[82] S. M. Shellow, *op. cit.*

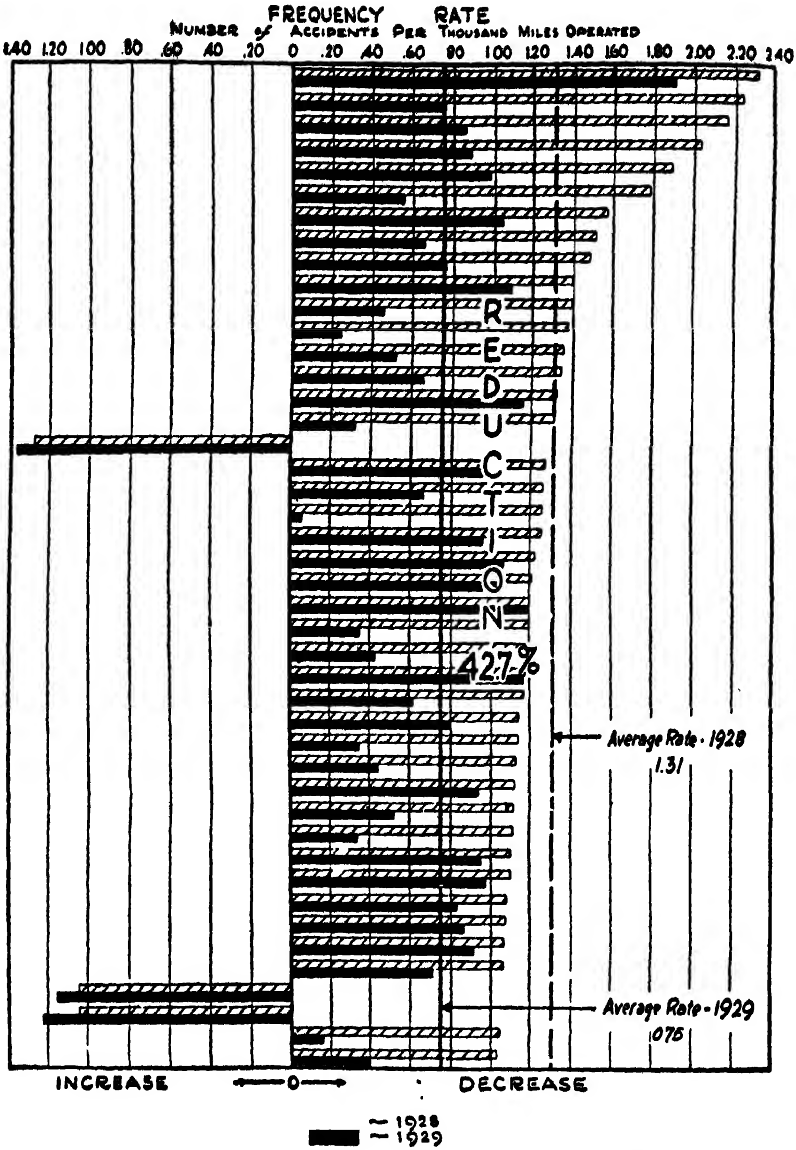


FIGURE 53. *Frequency Rates for Each of 44 Accident-Prone Motormen Showing Comparison Before and Following Study—1928 and 1929—Woodhill Division, The Cleveland Railway Company*

(From The Accident-Prone Employee, The Metropolitan Life Insurance Company, New York, 1930)

the employee which exists in his file. The data is summarized by the psychologist and, on the basis of a complete review of these findings, a program of re-instruction, or of medical care, or of social readjustment is outlined for each individual.

A follow-up of men examined at the clinic is maintained. During the first year of operation of the accident clinic, that is, from January 1st, 1929 to January 1st, 1930, reduction of accidents on the entire system of The Milwaukee Electric Railway and Light Company was approximately 25 per cent. Over the same period, a reduction in accidents of the special group studied in the clinic was 81.5 per cent. In addition, the average accident per man in this accident-prone group was reduced from 2.8 to .51 which is below the average for the entire system.[33]

An elaborate program of individual study and treatment of accident-prone drivers was undertaken in, 1927, by the Boston Elevated Railway Company, under the direction of Dr. W. V. Bingham[34] of the *Personnel Research Federation.* The methods employed in this study are essentially the same as those described above. It is based on the point of view that the "best approach to safety is the approach which places special emphasis on the individual. It recognizes the great variety of individual differences. In dealing with each motorman or each truck driver, or each automobilist, he is recognized not as one of the mass, but as a distinct personality, unique."

The value of this approach is clearly brought out in the fact that on the Boston Elevated Railway, as a result of the application of these procedures, the actual net savings in the cost of injuries and damages in 1929 as compared with 1928 amounted to $300,670.73. Collision accidents on bus lines and street railways have been reduced more than 35 per cent since this work was started in 1927. In January, 1930, all previous records were broken, collision accident records being reduced to 1.16 per 10,000 car miles, which is less than one-half of those for the same month in 1927.[35] The figure for 1931, as compared with those for 1926, show a 58 per cent reduction in collision of surface cars with trolleys; 54.4 per cent with pedestrians; 71.3 per cent with other surface cars; 36.8 per cent in boarding and alighting accidents and 23.6 per cent in all other accidents.[36] Accomplishments such as these, point clearly to the economic value growing out of the application of psychological methods in accident reduction. Associated with these economic returns are enormous social benefits in reducing the suffering and the general social maladjustment associated with personal injury resulting from accidents.

[33] *Ibid.* p. 215.

[34] W. V. Bingham, "Personality and Public Accidents, The Study of Accident-Prone Drivers," *Transactions Seventeenth Annual Safety Congress,* New York, 1928, pp. 7–8.

[35] *Safe Transportation, op. cit.,* pp. 1–4.

[36] From data furnished by Dr. W. V. Bingham.

SPECIFIC FACTORS IN ACCIDENT SUSCEPTIBILITY IN THE TRANSPORTATION INDUSTRY

Although the studies described above were primarily undertaken for purposes of individual adjustment, they have also resulted in the accumulation of data of extreme value in arriving at a more complete understanding of the nature of accident susceptibility.

A few illustrations will serve to give an indication of the character of this data, which cannot be cited in detail.

The studies agree in noting an inverse relationship between *experience* or length of service on the job and accidents in the transportation industry.[37] In the Cleveland study, men with 5 to 10 years of experience showed a combined rating of 0.84 accident per 1,000 car miles while those having less than 5 years service had a rating of 1.14 or 36 per cent higher.[38] However, as is pointed out by Slocombe and Bingham,[39] this relationship may be an artifact, inasmuch as the extremely incompetent and dissatisfied individuals are gradually separated from the job, leaving a larger proportion of more efficient and better satisfied men on the job with increasing years of service.

TABLE 52

Showing that Men who Operate Economically Tend to Operate Safely and also to give More Satisfactory Service

	NUMBER OF MEN	ACCIDENTS	DELINQUENCIES
Men with low coasting record	100	364	73
Men with high coasting record	100	313	46

(After Slocombe and Bingham)

The relationship between susceptibility and *age* is not as clear cut. There seems to be general agreement that age is not an important factor, although there is some indication that older men tend to have more accidents.[40] However, it is possible, as is again pointed out by Slocombe and Bingham,[41] that the relationship in this case is between the impaired physical conditions (most particularly high blood pressure) of the older men, rather than between age and accidents.

There are findings which favor the opinion that there exists a direct relationship between accidents and operating efficiency. In two separate studies of motormen [42] there appears a greater consumption of power

[37] *Preventing Taxicab Accidents, op. cit.*, p. 15.
[38] *The Accident-Prone Employee, op. cit.*, p. 7.
[39] C. S. Slocombe and W. V. Bingham, "Men Who Have Accidents," *op. cit.*, p. 7.
[40] M. S. Viteles, *Report to Philadelphia Rapid Transit Company*, May 26, 1927; C. S. Slocombe and W. V. Bingham, *op. cit.*; *Preventing Taxicab Accidents, op. cit.*
[41] C. S. Slocombe and W. V. Bingham, *op. cit.*, p. 5.
[42] *Accident-Prone Employee, op. cit.*, p. 7. C. S. Slocombe and W. V. Bingham, *op. cit.*, pp. 2–4.

by men with the high accident rate. In the Boston study there is also reported a direct relationship between accidents and the delinquencies records of the operators. The extent of this relationship as well as with consumption of power (indicated in poor coasting record), is shown in Table 52. The investigation of Cleveland [43] motormen fails to confirm this finding. However the observed relationship between the use of power and safety of operation is an indication that unsafe operation is usually inefficient operation.

In an earlier chapter the author has referred to the use of tests in the selection of motormen, and has described apparatus used for this purpose. In the application of such tests investigators are not primarily concerned with the experimental analysis of the mental traits underlying susceptibility to accident. Such an analysis, as has been pointed out, is necessary in the development of a test but, generally speaking, it is considered as incidental in the preparation of tests. The emphasis is upon the validity of the test in distinguishing between satisfactory and unsatisfactory operators, and not upon the mental traits which underly proficiency and safety in the operation of the motor vehicle.

In a recent study by Slocombe and Brakeman [44] a comparison has been made of performance in a series of selected tests of 43 high accident men and 43 low accident men, employed on the Boston Elevated Railway, mated with respect to age, length of service, hazards of route, etc.[45] The tests included measures of "perseveration," "oscillation," "speed," "accuracy," and "muscular control."

Perseveration, for example, was measured by choice reaction tests in which the subject was instructed to respond to a red light by pressing a button with his right hand, and to a green light by pressing a button with his left hand. The test was then repeated, the direction of response being reversed, that is, the right hand being used to respond to the green light and the left hand to the red light. The difference between the number of omissions and mistakes and the speed of reaction in the first and second tests was used by the authors as one measure of "perseveration." A number of other tests were at first employed as additional measures of "perseveration," but they were ultimately discarded.

"Oscillation," "speed," and "accuracy" were likewise measured by differential reactions to visual signals. "Muscular control" was measured by requiring the subject to pass a control handle through 8 notches in 9 seconds.

Elaborate data on reliability and an extended "apologia" on the significance of low coefficients of correlation between tests and criterion

[43] *Accident-Prone Employee*, *op. cit.*, p. 7.
[44] C. S. Slocombe and E. E. Brakeman, *op. cit.*, pp. 28–38.
[45] This investigation is a continuation of the study of accident-prone drivers started under the direction of Dr. W. V. Bingham, of the *Personnel Research Federation.*

are presented by the authors, who conclude from the fact that 8 of the high accident men made "poor" scores on the tests in comparison with 2 of the low accident men, that the tests are of value in diagnosing and in establishing the relationship between accident-proneness and test performance.

Weiss and Lauer [46] have undertaken an extensive study of psychological factors in automotive driving. The authors have viewed this investigation as a preliminary study and have concerned themselves largely with the development of apparatus and techniques which may be employed in the further study of the personality of drivers. The subjects examined included three groups: *Group A* consisting of 141 students and citizens examined during the fall of 1928; *Group B* of 84 students of Ohio State University, examined during the Spring of 1929; *Group C* of 132 students, citizens, truck drivers, and taxicab drivers. The subjects in *Group C* were used as a check on the first two groups. In all 357 subjects were carefully studied in the course of the investigation.

The procedures employed in this investigation and the results obtained are too varied for detailed description in this chapter. The procedures include a very carefully devised and controlled examination of automobile operation on the road. Among laboratory tests devised for the purposes of this study is an apparatus for measuring eye, hand, and foot co-ordination; a pursuitmeter; a psychogalvanometer; an especially constructed miniature highway for testing the estimation of velocity; etc. A number of physiological tests and sensory tests such as measurement of pulse; the measurement of near and far vision; of ocular balance, etc., were also included. The study also involved an attempt to differentiate the social characteristics of convicted automobile drivers. On each test a careful comparison was made between "accident" and "non-accident" groups.

According to the investigators in this study on the nature of susceptibility to accident [47] "the following tendencies seem established and at least indicate the direction of future research."

1. Single defects do not account for accident-proneness. It is possible that "any one defect may be duly compensated by other adjustments, especially if the driver knows his limitations."

2. Nervousness is a major cause of accidents especially when associated with poor motor co-ordination. Nervousness is used in a broad sense, referring not only to actual organic disturbance, but to unsatisfactory adjustment resulting from home or social conditions.

3. Visual defects do not appear to be of importance in themselves, although constituting a strain on the driver which may result in accidents. Esophoria is most often associated with accident-proneness.

[46] A. P. Weiss and A. R. Lauer, *op. cit.*
[47] *Ibid.* p. 145.

4. Low vitality frequently results in inattention which constitutes the major factor in certain types of accidents.

5. It is pointed out that the safe operation of motor vehicles is partly a matter of education. "The actions of the expert and safe driver are too complex to justify the hope at this time that there is any very simple measurement which will indicate his skill." The licensing problem, according to these investigators, involves, for the present at least, the use of road tests, which can be gradually simplified to a laboratory performance.[48]

6. The final conclusions of the investigators point to the extreme complexity of the problem of safe motor vehicle operation. The importance of procuring the co-operation of private concerns employing many drivers and of the various political agencies in the further investigation of the problem is stressed. The inadequacy of state laws, in emphasizing physical characteristics of the driver in the licensing of automobile operators, is pointed out.

The type of laboratory study developed by Weiss and Lauer [49] satisfies a great need in the complete analysis of accident susceptibility. Under laboratory conditions it may be possible to refine the analysis to an extent impossible in the industrial situation. At the same time, it must be recognized that the most important contributions to date in the analysis of accident-proneness in the operation of motor vehicles has come from within the transportation industry. There is reason for hopefully awaiting a more complete understanding of the complexity of this problem from the continued co-operation of universities and industrial research centers in its investigation.

SEX DIFFERENCES IN PRONENESS TO MOTOR VEHICLE ACCIDENTS

The employment of women in the taxicab industry has made possible the investigation under controlled conditions of sex differences in proneness to motor vehicle accidents. This study,[50] made by the author with the assistance of a graduate student, represents a comparison of accident records of men employed by the Yellow Cab Company [51] and of women employed by the Cunningham Cab Company of Philadelphia both operating, at the time of the study, under Mitten Management.

On very few questions is opinion so dogmatic and so unsupported

[48] In considering this conclusion, it is of course important to note the predictive value of selection tests which have been successfully employed in the transportation industry. It is true that these tests are not "simple in character," and it is possible that the authors had this in mind in drawing this conlusion.

[49] A. P. Weiss and A. R. Lauer, *op. cit.*

[50] M. S. Viteles and H. M. Gardner, "Women Taxicab Drivers," *Pers. J.*, 7 (1929), pp. 349–55.

[51] The study was made possible by the kindness of E. S. Higgins, General Manager of the Yellow Cab Company of Philadelphia, whose co-operation is gratefully acknowledged.

by factual data as on that of the relative safety of men and women automobile drivers. There appear to be only two opinions: (1) that men are safer drivers than women; (2) that women are safer drivers than men. Of these, the first, in general, seems to be the opinion held by men, and the second that of women drivers.

The question is of some importance from the viewpoint of the general problem of sex differences, and also, by reason of the tendency to substitute women for men as operators of motor vehicles. This tendency has shown itself in the appearance in recent years of women taxicab drivers in a number of cities of the United States and of Europe, and of women street car drivers in a number of European cities.

The chief purpose of this study was to compare men and women taxicab drivers. As a preliminary to this investigation, comparative figures on operators of non-commercial vehicles were sought from insurance companies, automobile clubs, and state highway departments. It was found that only meagre data of this sort was obtainable, but the available evidence *appeared* to favor the woman driver. So, for example, a report issued by the Department of Motor Vehicles of the State of Connecticut for 1927, shows that although about 20 per cent of the drivers' licenses are held by women, the latter were involved in only 9.6 per cent of the accidents during the year. In the District of Columbia women, representing 15 per cent of the licensed operators, were during 1927 responsible for only 6 per cent of the non-fatal accidents and 2.4 per cent of fatal accidents.

Similar evidence from other States *seems* to favor the women drivers. However, it is clear that this evidence is inadequate, inasmuch as it fails to consider important differences between men and women in operating conditions. It is safe to assume that the average number of miles covered by male operators is considerably in excess of the average number covered by women drivers. Men drive in heavier traffic and operate more frequently in stormy weather than do women. Only male drivers operate trucks and other heavy vehicles, in the case of which the proportion of accidents is greater than among lighter vehicles. It is with a purpose of avoiding such variables that the study described immediately below was undertaken.

The study covered a period of 11 months, between March 1st, 1927 and February 28th, 1928. Figures for December, 1927, were not included because during that month women drivers were transferred from the company by which they were originally employed to another with which a merger was being made. For this reason complete figures were not available for that month.

The number of male drivers employed at any time was about 2000. The maximum number of women cab drivers employed was 40, the number varying from 35 to 40 in the period covered by this report. Although only a maximum of 40 women were employed at any one time, the records included in this report actually deal with the per-

formance of approximately 150 women who were hired in the course of the year to maintain the standard working force of 40.

Conditions of work were almost identical for men and women. Both operated the same type of taxicab. The mechanical condition of the cabs was carefully checked as part of the maintenance policy of the companies. Women as well as men operated in all kinds of weather and traffic conditions. Women, however, were not employed on the night shift.

In one important respect there existed a difference between men and women drivers. In the case of men it has been the custom of the company to employ only those who possessed a driver's license in Pennsylvania and who were able to pass a fairly well standardized driving examination prior to employment. In the case of women such a regulation was not applied. A number of the women operators were not experienced in driving when hired. They were given a very thorough course of training in driving and placed on cabs immediately after training.

Records are not available to show the percentage of accidents for which these newly trained drivers are responsible. Throughout the entire year of operation, however, only 30 inexperienced drivers were placed under instruction. Of these, 22 completed instruction and were placed on the cabs. In other words, about 14 per cent of women drivers placed on the cabs during this period were inexperienced. On February 1st, 1928, 10 of these drivers were still on the payroll.

It is impossible to determine the exact effect of this variable on the observed difference in accident rate between men and women drivers, but it is unquestionably a factor to be considered in the interpretation of the figures submitted in this report. However, the highly selected character of this relatively inexperienced group, the thoroughness of the training given to the women, and the small percentage of inexperienced drivers in the whole group of women, suggest that it should not be weighted too heavily in the consideration of this data.

In Table 53 is presented an analysis of the average number of accidents per 1000 miles and per $1000 revenue of men and women taxicab drivers. An examination of the table shows that women taxicab drivers were responsible for three times as many accidents per 1000 miles as men, and three and a half times as many accidents per $1000 revenue as were men.

It seemed interesting to investigate the question of whether the accidents in which women are involved were as serious as those involving men. This investigation could not be extended to the entire period covered by this study. An analysis of accident cost, however, for men and women drivers for one month (November 1927) showed the average cost per accident of men to be $31.83 per thousand miles, whereas that of women was $15.76. In the case of cost per thousand dollars of revenue the figure is $5.77 for men and for women $2.68.

These cost figures do not include legal expenses or the cost of unsettled claims. Furthermore, the figures cover too short a period to be conclusive. They do *suggest,* however, that the accidents in which women are involved are, on the whole, less serious than those in which men are involved. This evidence is in favor of a not uncommon opinion that women, through over-cautiousness, cause accidents on the part of fellow-drivers. In such accidents the women drivers involved naturally have no damage charge against the vehicle operated by them. This is possibly further borne out by the fact that the proportion of accidents followed by claims is smaller in the case of women than in the case of men drivers.

TABLE 53

Comparison of accidents to men and women taxicab drivers

TIME	ACCIDENTS PER 1000 MILES			ACCIDENTS PER $1000 REVENUE		
	FEMALE	MALE	RATIO F:M	FEMALE	MALE	RATIO F:M
1927						
March	0.366	0.251		3.02	1.49	
April	0.851	0.256		5.55	1.41	
May	0.649	0.275		4.93	1.51	
June	0.314	0.231		2.23	1.27	
July	0.608	0.226		4.43	1.41	
August	0.954	0.255		9.98	1.23	
September	0.911	0.248		5.01	1.43	
October	1.278	0.263		7.75	1.46	
November	0.857	0.250		5.04	1.41	
1928						
January	0.721	0.274		4.07	1.46	
February	0.897	0.276		5.80	1.54	
Total	0.767	0.257	2.98	5.063	1.449	3.49

(After Viteles)

The figures obtained in this comparison of men and women taxicab drivers favor the point of view that the present generation of women drivers is more susceptible to accidents than the present generation of men drivers. The extent to which this is the result of relative inexperience in driving, or of a sex-determined difference in susceptibility to accidents in traffic, cannot be finally determined from an examination of the present data. The fact, however, that a sampling of women suffers more accidents when driving under the same conditions as a somewhat similar sampling of men is clearly established.

XIX. THE ACQUISITION OF SKILL

INTRODUCTION

Training is among the principal factors in increasing efficiency and improving individual adjustment in industry. A well-organized training program, based on a sound analysis of the job and applying well-established learning principles, enables the worker to employ the most effective methods in the performance of his task. Systematic instruction speeds the rate of acquisition of skills and thereby reduces the time required for training.

Shortening the training period not only decreases the cost of instruction, and incidental waste in the form of spoiled material, overhead on machines, etc., but serves to increase the stability of the working force and the satisfaction derived from work, particularly in the case of highly specialized tasks of modern industry.

The subdivision of work has created a great number of specialized tasks in which skill must be quickly acquired if the worker is to meet the production standards of the plant. It is possible, as Link [1] has suggested, that at least one-half, and probably more than half the jobs in industry fall within this group. The job of the skilled machinist of yesterday has been converted, by a long process of division, into screw-machine operation, assembly, drill press operation, reaming, punch press operation, polishing, etc. This subdivision applies also to office work in which the old-fashioned job of clerk has been split into the positions of time clerk, auditing clerk, filing clerk, pay roll clerk, posting clerk, computer, ledger clerk, sorting clerk, billing clerk, etc., each requiring specialized training. On such jobs, in particular, turnover and dissatisfaction are increased by the failure to provide training which enables the worker quickly to profit from the higher wages, generally on a piece work basis, attainable only when the employee has reached a level of effective workmanship. Moreover, on jobs involving more complex patterns of motor response and the acquisition of considerable knowledge, the most favorable conditions of learning must be employed to facilitate the integration of well-adjusted response [2] characteristic of all forms of skill.

Misled by the simplicity of the task industry was inclined, in the early days of mechanization and specialization, to neglect systematic

[1] H. C. Link, *Education and Industry*, New York, 1923, p. 126.
[2] T. H. Pear, "The Nature of Skill," *J. Nat'l Inst. Ind. Psych.*, 4 (1928), pp. 193–202.

training as unnecessary in the development of skill. Apprenticeship systems were discarded and nothing provided to take their place. Observation of other workers and casual instruction by supervisors and associates were regarded as the sole procedures necessary for learning the job. The insistence of Taylor, Gilbreth, and other early exponents of scientific management [3] upon the importance of instruction and their success in using training as an aid in increasing production helped to awake a recognition of the value of systematic instruction in developing and maintaining an efficient and satisfied working force. This has led industry to substitute for the old methods of training, in which instruction of the worker was largely left to the caprice of the foreman or fellow-worker, systematized training programs developed and administered under the direction of training specialists.[4]

Instruction in the industrial plant may be divided into two types: (a) *general training*, and (b) *job training*. The first includes instruction in plant policies, in academic subjects related to work, courses in plant organization and management, Americanization programs, and a variety of other courses broadly cultural or developmental in character. The purpose of job training, with which this chapter is primarily concerned, is to promote trade mastery—to teach the worker how to do his job. Such training may range from one hour or two of instruction on a simple task to three or four years of apprenticeship in a highly skilled trade. It may include the very simple movements required in the operation of an elevator to the great variety of complex co-ordinations and breadth of knowledge combined in pattern making.

The tendency in recent years has been to centralize training under the supervision of the personnel or industrial relations department. In so far as actual instruction is concerned it may be given in a "vestibule school," in which the worker is trained apart from the shop or office in which work is done on a production basis. The vestibule school has been recommended by Link [5] and others as particularly suitable for training in repetitive operations of both a shop and office character. It permits an emphasis upon training rather than upon production.[6] It makes it possible to train workers without interfering with the production of men who have already been trained. It also allows an opportunity for observation of the temperamental and other qualities of new workers which affect their adjustment in the plant. In other cases, although supervised by a central agency, training is de-centralized,

[3] See Chapter II, pages 10–12.

[4] J. H. Greene, *Organized Training in Business*, New York, 1928, pp. 335; N. Peffer, *Educational Experiments in Industry*, New York, 1932, pp. 206.

[5] H. C. Link, *Employment Psychology*, New York, 1919, pp. 288–289.

[6] The "vestibule school" has recently been elaborated in Germany into a "central training workshop." This is a self-contained plant devoted exclusively to training apprentices in the metal trades under active working conditions, but free from the disadvantages present in a factory employing adult experienced workers. The DINTA system, administered by the *Deutscher Institut für technische Arbeitsschulung* is described in a recent article by J. H. Currie, "The DINTA System," *Human Factor*, 6 (1932), pp. 122–126.

being given in the workroom by instructors who form part of the operating department or who are members of the personnel staff.

The advantages and disadvantages of these two forms of training cannot be discussed at length in this volume. However, it is interesting to note that although the vestibule form of training was most favored in the early days of personnel management, particularly during the War, there now appears to be a trend in the direction of decentralized training in the shop. In addition, there is an increasing tendency to place the administrative responsibility for training into the hands of the department in which the employee is working. It is felt that training is the direct responsibility of the operating departments, to be carried on by the supervisory force or instructors who are members of such departments, appointed by operating executives and directly responsible to them for the administration of the training course. However, in the development of training programs operating departments are aided by specialists attached to the personnel department, who aid in the organization of individual training programs and in the co-ordination of training throughout the organization and provide staff supervision in the systematization of training, its extension, and development.[7]

PSYCHOLOGICAL METHODS IN TRAINING

Although the value of training may be recognized and the attempt made to organize it, much of its beneficial value may be lost through a failure to apply psychological principles of learning in the development of skill through training. This is well illustrated in the methods ordinarily employed in training motormen in the electric railway industry.[8] The safety with which a trolley car is operated depends upon the integration of habits of response during the training period. The purpose of devoting a period of two or three weeks to training the motorman is to promote the integrated co-ordination of these responses. They must be so firmly established and co-ordinated that when the motorman goes out on the road alone, in full charge of a street car, he performs them without the intervention of consciousness, that is, without thinking, "Now I must turn this handle this way, and step on the plunger," etc., when a given situation arises. The responses, the habits, must be so well fixed that each stimulus, whether it be a child crossing the track, the sound of the conductor's bell, or the sight of an overhead circuit breaker, will bring at once the appropriate and correct response—the correct series of movements properly co-ordinated.

The usual procedure adopted by many street railway companies in

[7] M. S. Viteles, "Training Technical Employees," *Gas-Age Record*, 68 (1931), pp. 235–39.
[8] M. S. Viteles, "Application of Psychology in Training Workers," *Lefax*, (1923), pp. 29–36.

training motormen is somewhat as follows: The apprentice spends a half day or a day in a schoolroom—ordinarily an old car fitted up for this purpose. Here he is taught the simple operations of starting and stopping a car, the meanings of signals, the uses and locations of fuses, the use of the fender, and similar details of operation. He is then assigned to a "run" with a motorman chosen by reason of his record for the instruction of apprentices. He spends a day with the motorman, watching him run the car and running the car himself under the direction of the motorman. For a period of ten days to two weeks this procedure is continued, the apprentice being assigned each day to a different motorman on a different run. The purpose of placing the apprentice with the different motormen is to give him contact with a number of experienced, trusted men, from whose example he may profit, and at the same time to enable him to learn something about the different routes, the special difficulties of each, etc.

The effect of assigning the new man to different motormen each day in this way is, however, from the point of view of the psychologist, most harmful. Experimental studies of learning have shown that when opposing associations are alternately practiced, they have an interference effect upon each other, particularly during the early practice period. In other words, the formation of a habit is interfered with if other responses, antagonistic to the one being learned, are practiced along with it. The formation of a habit may also be interfered with by one already established. In the first stages of learning to use the typewriter, for example, it is easier for one who has never used a typewriter to learn to employ the best methods in typing than one who has already practiced on it, using one or two fingers or some similar amateur method.

In the procedure for training motormen described above this law of habit interference is overlooked. It was found by the author, who learned to run a street car as a preliminary step to the preparation of a test for the selection of motormen,[9] that practically each of the motormen under whom he took training had his special "tricks"—individual ways of handling the controller and the air-brake handle. Instead of receiving from day to day uniform training in a definite series of responses involving the same muscular combinations, there were variations in the patterns of response employed from day to day. For handling the air brake, for example, one motorman recommended taking "long bites" of air, another recommended "short bites." One man employed one technique, involving one series of muscular actions, for closing the door and starting the car simultaneously; another had a second method, involving another, almost antagonistic series of muscular responses. The total effect was to create interference in habit formation—a condition which retards the development of skill, lengthens the training period, and promotes an uncertainty of

[9] See Chapter XIV, pages 291–97.

response which continues after the close of the training period, to the danger of the public and of the operator.

There are a number of training methods that can be used in overcoming the disturbing element in the training program described above, but each of them, in order to bring results, must apply the knowledge of the learning process contributed by the psychologist to industry. In the development of all kinds of skill—in wrapping bundles, in working a punch press, in examining ball bearings—the training program is of utmost importance in the development of proficiency—and an important feature of the good training program is a consideration of the psychological factors involved in the acquisition of skill.

THE PROGRESS OF LEARNING

The most important factor in the acquisition of skill is *practice* or *repetition* of the task. If one has the ability to perform an operation its repetition, up to a certain point, makes him more and more skilful.[10] An important finding of psychological investigations in the laboratory and in the industrial plant is that the acquisition of skill follows a regular course. If the production or attainment of the individual is plotted at various intervals in the learning period there is obtained a *learning* or *practice curve* with certain characteristic features. The character of this curve is illustrated in Figure 54A, showing the improvement in telegraphy over a 32 week period in a classic experiment by Bryan and Harter.[11] That the general trend of the curve remains constant with various types of activity is illustrated in Figure 54 B, showing the improvement of typewriting by the touch method and in Figure 54C, a practice curve obtained in mirror drawing. Among the characteristic features of the practice curve are:

(a) *Improvement in work with practice, shown by the rise of the curve to the right.*

(b) *Variations in rate of improvement or gain from practice in various parts of the learning period.* So for example, in Figure 54A, representing the type of curve most frequently found when the effect of practice is recorded, progress is shown to be rapid at the outset and to become slower in the latter part of the training period. Such a curve is said to exhibit *negative acceleration.* In contrast, in Figure 54C, improvement is shown to be more rapid at the end of the learning period than at the beginning.

Such variations appear to depend largely on the relation of the processes involved in learning to those which have played a part in the

[10] E. S. Robinson, "Factors Affecting Human Efficiency," *Ann. Amer. Acad. Pol. Soc. Sci.*, 110 (1923), p. 101.

[11] W. L. Bryan and N. Harter, "Studies in the Psychology and Physiology of the Telegraphic Language," *Psych. Rev.*, 4 (1897), pp. 27–55; 6 (1899), pp. 345–75.

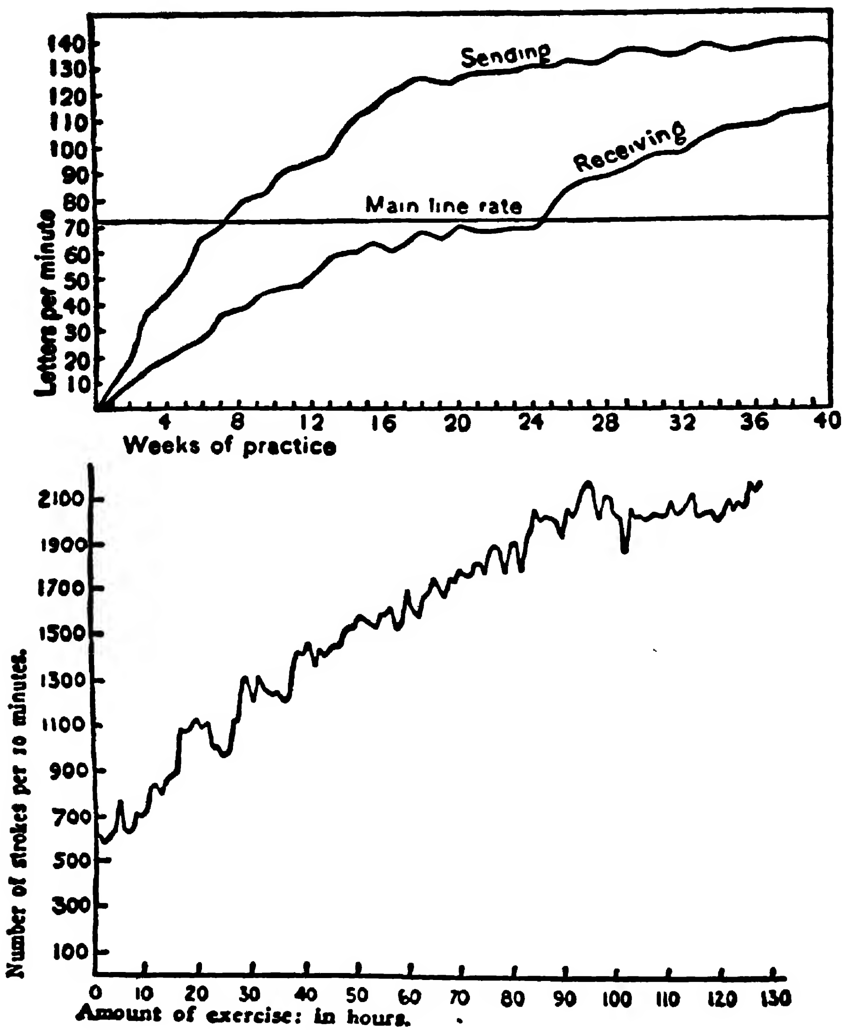


FIGURE 54. *Practice Curves*

A. *In Telegraphy*

(*After Bryan and Harter*)

B. *In Typewriting by the Touch Method*

(*After Book*)

acquisition of other skills by the learner.[12] According to Freeman,[13] Pear, and others, if a previously learned movement can be applied unchanged, progress will probably be rapid at first and slow afterwards as the limit of possible improvement, or the *physiological limit* of training is reached. If it is necessary fundamentally to reorganize a

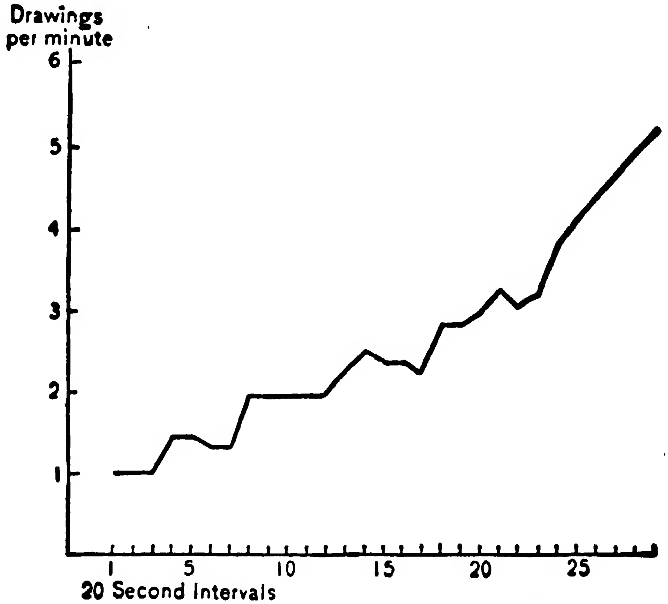


Figure 54. (Continued) *Practice Curves*

C. *In Mirror Drawing*

(*After Pear*)

movement, learning is likely to be slow at the beginning and to increase in the latter part of the practice period before reaching a point at which it again slows down.

(c) *Another feature of many practice curves is the appearance of plateaus, or flattened sections showing an absence of improvement in spite of continued practice.*

A study of the literature reveals a difference of opinion among workers with respect to the factors accounting for the *plateau*. So for example, Bryan and Harter [14] supported by Swift,[15] have favored the viewpoint

[12] T. H. Pear, *Skill in Work and Play,* New York, 1924, p. 50.
[13] F. N. Freeman, *How Children Learn,* Boston, 1917.
[14] W. L. Bryan and N. Harter, *op. cit.*, pp. 27–55; 6 (1899), pp. 345–75.
[15] E. J. Swift, "Studies in the Psychology and Physiology of Learning," *Amer. J. Psych.*, 14 (1903), pp. 201–51. "The Learning Process," *Psych. Bull.*, 4 (1907), pp. 307–10.

that the plateau is the result of a play of forces inherent in the learning process. In contrast is the theory, originally formulated by Johnson,[16] that the plateau represents a temporary failure in attention and effort on the part of the subject. This viewpoint assumes that if the subject could be induced to sustain the same effort day by day during the practice or learning period there would be no plateaus.[17] This point of view has also been generally supported by Book [18] whose examination of introspective reports and pulse rates suggested that less effort was actually put into work at all stages of practice where little or no improvement was made.

The question of whether the plateau is an essential part of learning is of extremely practical significance in industrial training. The objective of systematic training is to promote the rapid acquisition of skill and final integration of response at the highest possible level. The plateau marks a level of arrested progress, affecting adversely the general rate of acquisition of skill. Moreover, a plateau appearing early in a practice period may become permanently established in the form of a *final plateau,* representing a stabilization or final integration of response at a level of efficiency below the individual's physiological limit of learning and below the production standards of the plant. For these reasons, in the organization of industrial training programs, it is important to know whether the plateau occurs because of a loss of attention or decreased effort; by reason of the unsatisfactory arrangement of practice; or whether it is an essential feature of learning not subject to the influence of such *extrinsic* factors in training as incentives, arrangement of co-ordinated movements, etc.

Recent experimentation has suggested that the situation is complex and that a number of factors affect the appearance of the plateau. The complexity of the situation has been recognized by earlier exponents of the extreme positions. Book, for example,[19] has found that plateaus do occur at critical stages in the learning process, that is, where new and increased difficulties are met. Moreover, Bryan and Harter [20] mention the fact that in telegraphy operators whose receiving rate has been on a level for years frequently increase their rate when forced to do so in order to secure and hold a position requiring higher skill. An analysis of experiments in this field suggests that whether or not incidental plateaus appear, and to some extent the level of the final plateau depend upon:

(a) *The relative simplicity or complexity of the task.* (b) *The exer-*

[16] W. S. Johnson, "Researches in Practice and Habit.," *Yale Psychol. Studies,* 6 (1898), pp. 51–103.

[17] Cited from M. D. Smith, "Periods of Arrested Progress in the Acquisition of Skill," *Brit. J. Psych.*, 21 (1930), p. 2.

[18] W. F. Book, *The Psychology of Skill,* "Univ. Montana Studies in Psychology," 1 (1908), pp. 211.

[19] W. F. Book, *The Psychology of Skill,* New York, 1925, pp. 257.

[20] W. L. Bryan and N. Harter, *op. cit.*

cise of effort and attention in practice, determined, in part, by the incentive. (c) *The number of practice periods.*

The effect of the *complexity of the task* is indicated, for example, in the fact that plateaus appear most frequently in forms of learning which require a combination of activities, and in which progress or training is marked by the development of such combinations. "If a heterogenous task is composed primarily of two levels of complexity, one part rather simple to learn while another part is more complex, then the simple part may be learned almost to perfection before the complex part is begun. Such a heterogenous task will show a plateau. The plateau may also be found, although less pronounced, when two such tasks are started simultaneously." [21] So, for example, there is no evidence of a plateau in sending telegraphic messages (Figure 54A), although a very marked levelling off of the practice curve is noticeable in the middle portion of the curve for receiving messages. As Pear points out,[22] in sending, the matter to be transmitted exists as a whole and has to be broken down into constituent letters by ordinary every-day mental processes which are used every time one writes. In receiving, on the other hand, it is customary to learn groups of sounds corresponding to each letter which must finally be organized into larger wholes for the apprehension of words or phrases. The plateau may represent a stage at which such integration is carried through, on a level of internal mental organization of a high order.

From the consideration of such facts "it is possible to assume that if habits of higher order could be formed earlier in the process of learning, plateaus might be considerably shortened. If the plateau be the consequence of artificially separating, for teaching purposes, habits of lower and of higher order, it would be wise to inquire how far such separation is necessary." [23] The possibilities in this direction have been indicated by the investigation of typewriting, in which the plateau has been eliminated when the pupil learned from the outset words instead of isolated letters.[24] Likewise in industrial training, the procedure of using highly organized tasks, instead of breaking them into simpler, constituent units may facilitate the acquisition of skill through the elimination of unnecessary plateaus, and actually raise the level of the final plateau. This aspect of training will be discussed further in Chapter XX in considering *whole-part* methods of learning.

THE INFLUENCE OF INCENTIVE UPON PRACTICE

The results of many investigations show that *attention, effort,* and *incentive* play a part in promoting or arresting progress during train-

[21] L. L. Thurstone, "The Learning Function," *J. Gen. Psych.*, 3 (1930), p. 489.
[22] T. H. Pear, *Skill in Work and Play,* New York, 1924, p. 50.
[23] *Ibid.*
[24] J. W. Barton, "Comprehensive Units in Learning Typewriting," *Psych. Monog.*, 35 (1926), No. 164, pp. 47.

ing. The influence of direction of attention is shown in an experiment by Trow and Sears [25] in which a subject sorted a pack of 52 cards into 4 piles for one hour each night. Practice was maintained for 10 days; followed by an interval of 24 days with no practice; another interval of 10 practice days; a second interval of 40 days without practice and a final interval of 9 practice periods. In all there were 29 practice periods including 174 trials in which 9048 cards were dealt. The first 7 practice periods, involving 42 trials, showed marked fluctuations but no improvement in rate of dealing. An analysis by the subject showed fluctuation to be the result of experimentation with methods of dealing, characterized by shifts in focusing attention upon one or another aspect of the dealing activity. The adoption of a uniform method of dealing was immediately followed by a marked improvement which was maintained until the 40 day pause in practice. The authors point to the implications of this experiment in showing clearly the advantages of instruction in directing attention immediately upon the best method or methods of work as an aid in cutting down the time required for learning. Fruitless trial and error can be avoided in this way and repetition limited to the most effective series of co-ordinated movements. This necessarily involves an analysis of the task for the discovery of the most effective movements—a feature of training to be discussed in Chapter XX.

The character of laboratory investigations in this field is also illustrated in a recent study by Smith,[26] who employed tasks of three types to gain further evidence as to the existence and cause of plateaus. The first, the *Ringball* game, consisted essentially of throwing a rubber ball into a target on the wall or causing it to bounce into a target on the floor. The game was so arranged that fresh elements could be introduced at various times in order to complicate the task and to study the process of co-ordinating new with older elements. The second task, known as *Guidit,* consisted in guiding accurately and quickly as possible, a small metal ball up to the top of an inclined plane by means of a knitting needle set in a thin wooden handle.[27] On the surface of the plane were 21 holes each large enough for the ball to fall through. Interspersed among the holes were small wooden barriers to be circumvented by the subject. The performance was scored in terms of time and of the point reached on the board. The third task, in which the subject was required to practice a phonetic system of *shorthand,* involved mental as well as muscular learning.

Fourteen subjects were employed; 9 on the first task, 2 on the sec-

ond and 3 on the third. Long periods of practice were employed on each task. For the purpose of this study a plateau or period of arrested progress was defined as any period during which the score did not improve for 6 or more successive practices. Applying this definition, 71 periods of arrested progress were found in the records of total scores on the 3 tasks.

An examination of introspective reports and of the objective scores leads the investigator to conclude that 43 or approximately 60 per cent of the periods of arrested progress were due to incidental objective and subjective factors such as emotional strain, failure of incentive, weather, noise, light, illness, relearning after a vacational break, and, in one case, possibly to the attainment of the physiological limit of learning. The remaining 40 per cent of periods of arrested progress or plateaus are apparently inherent in the learning process itself. The two factors found to be most important in arresting progress include:—

1. Conscious *concentration of attention upon a single component* of a complicated task, which appears to interfere with progress in developing skill with the task as a whole.

2. *Involuntary interaction between two or more components* of a task in which habits were carried over from one to the other. This appeared particularly in the form of a carry-over of errors of the new movement to the old movement and the adaptation in the new movement of the rhythm and habits of the old movement at a stage when these were unsuited to the new movement.

From this study the author concludes that "in a wide sense all these causes of plateaus may be summed up in the phrase 'difficulties of co-ordination'—a successful co-ordination seeming to involve a certain distribution of attention and a certain ratio of skill between the individual components. Periods of arrested progress tended to occur when the subject regarded the task as made up of separable components, but not when the task was regarded 'as a whole.' "[28] These findings and conclusions not only show the effect of attention, but reveal again the influence of the simplicity or complexity of the task and relations between component parts in determining the course of learning. The results are also significant in relation to the whole-part problem of learning, to be discussed in greater detail in Chapter XX.

The general effect of *motivation* upon gain from repetition is illustrated in a somewhat unusual experiment by Knight and Remmers.[29] The subjects were 10 college freshmen who had been subjected to a strenuous regime of humiliation and fatigue duties in the course of their probationary period as pledges of a fraternity. The administration of a strong dose of physic, a fake branding, withdrawal of per-

mission to shave or bathe, the carriage of bulky articles, liberal sprinkling of asafoetida, interference with sleep, long hikes, were included on the schedule of a probationary period which lasted from Monday to Friday inclusive. The experiment was carried out late Friday night. The group was given the Thorndike addition test, consisting of 48 columns of 10 addends with 1's and 0's omitted. The members of the experimental group were told by a fraternity officer that they were to assist in a scientific experiment and that they were to push themselves to the limit as the scores were involved in election to the fraternity. The subjects worked for a period of 2 hours with a 10 minute rest period and light refreshments at the end of the first hour. At the end of each 5 minutes a signal was given and the subject marked the point reached on the test. At this time the subject indicated by a letter rating of from A to F his feeling-tone, A indicating a feeling of general well-being, C a neutral attitude, F an extreme feeling of discomfort. During the last five minutes of work an attempt was made to obtain an end spurt by urging the men to further effort. The same procedure was followed a few days later with a group of 54 college juniors constituting a control group. An average of 21 columns per 5-minute period for the freshmen as against an average of 11 for the juniors can apparently be explained only on the basis of a more definite motivation of the first group, inasmuch as there is no reason for suspecting that the freshman group was inherently better in the trait measured than the larger junior group. The amount of difference is particularly significant in view of the "fatigue" condition of the freshman group. The percentage of correct answers is approximately the same for the two groups. Adequate motivation is shown to constitute an important force in learning.

Supplying information on the progress of improvement with practice appears often to be a satisfactory technique for motivating training and thereby eliminating incidental plateaus. The value of supplying information to workers as an incentive to increased production with practice is shown in a training program for Hollerith machine operators developed by Bolt in which production was more than doubled, partly through the use of this motivating device.[30] Its effect is shown more specifically in an investigation by Ross [31] who divided a group of 59 college students of psychology into 3 groups and required each to write groups of 4 vertical lines crossed with a fifth, as quickly as possible. Each group was given a preliminary practice period of one minute and an additional practice period of the same length for each of 12 days. The preliminary practice period was used to establish 3 groups equal in ability. One group was then given full knowledge of

its progress from day to day. The second group was given partial information of progress, the third was given no information concerning progress. Each group was urged to maximum performance on the test. At the end of the tenth practice period the group with full information had an average corrected score of 57.4; that with partial information an average corrected score of 54.3; and that with none an average corrected score of 53.2. From the first practice period to the tenth inclusive, the section with full information gained from 2.2 per cent to 8.5 per cent more than the section with only partial information, the average advantage being 6.2 per cent. The section with full information gained from 4.5 per cent to 12.6 per cent more than the section with no information, the average advantage being 8 per cent. In addition, in this experiment the effect of having received the information continued for 2 additional practice periods when information about progress was withheld from the group which had received it.

The effect of financial incentives in promoting steady improvement with practice is revealed in an investigation by Flügel [32] in which 46 school children worked on Kraepelin's adding sheets for 20 minutes on each of 46 successive week days. The subjects showed steady improvement even toward the end of the experiment and the practice for the group showed no evidence of a plateau. The chief reason for this appeared to be the monetary reward given each subject every time he broke his own record—an incentive more than sufficient to counteract the effect of influences responsible for arrested progress in practice.

An interesting sidelight on the influence of incentives upon learning appears in an experiment designed to test the relative value of punishment and reward upon learning, conducted under the direction of Thorndike [88] at the Institute of Educational Research. In one phase of this study, a subject who knew no Spanish was shown a Spanish word followed by 5 English words, one of which was the correct translation, and was instructed to choose one of the 5. He was punished either by an electric shock or in some other way if the response was wrong, and rewarded by a simple announcement or by a payment of money when the correct response was chosen. The same procedure was followed in the case of 200 words, which were repeated until a criterion of learning was met. Under these conditions it was found that a right response that is rewarded on the first trial causes an increase in from 1 chance in 5 to about 2 chances in 5 for correct repetition. A punished wrong response in Trial 1 produces no change in the chances

for a correct repetition for the response. In other words, punishment does not ordinarily decrease the likelihood of a repetition of a mistake in learning. Reward, on the other hand, strengthens the tendency toward the correct response.

The findings suggest that, in training workers, better results can be obtained by offering a suitable incentive for accurate performance than by enforcing penalties for mistakes. The results are also of significance from the viewpoint of developing proper attitudes in workers.[34] Punishment may not only be void of positive value, but may have the negative effect of inducing the worker to conceal his mistake and to adopt an unfavorable attitude toward the foreman and toward the plant. Rewards, on the other hand, not only strengthen the tendency toward correct performance but tend to build up favorable feelings.

The direct influence of incentive upon arrested progress in the industrial situation is shown in a report by Kitson [35] who examined the production records of 40 hand compositors with experience ranging from 1 to 27 years (8 years average) in a printing establishment. Average output at the end of 1 week was 55 units on a scale of efficiency established by preliminary time studies. An incentive system of payment was instituted, permitting workers to earn a bonus of two-thirds of one per cent on the flat rate for every unit of production above scale unit 75. Within 5 months these *experienced* workers reached the 97-unit point on the scale. At the end of one year and a half average output had reached 103 points, a level at which production had been stabilized during the last 9 months of the period of investigation. Production on the part of the experienced workers increased, according to Kitson, because the financial incentive led them *to improve their work and to learn new methods of doing it.* In the case of this group the elimination of wasteful and time- and effort-consuming movements proceeded spontaneously, without the aid of instruction in choice of methods which might have served to increase production earlier and to promote a higher ultimate limit. The fact that younger men with less experience actually achieved a higher average production as compared with older, more experienced workers is ascribed to the greater capacity or willingness of the former to adopt improved methods when urged on by an adequate incentive.[36]

In the absence of adequate motivation for continued improvement these workers had settled down to a relatively constant production rate at a level below their physiological limit of improvement. In the presence of a suitable incentive additional spurts in learning led to settling at a higher plateau level the height of which, it is conceivable, might be raised still further by other changes in conditions of work.

OTHER FACTORS IN ARRESTING PROGRESS WITH PRACTICE

In addition to the factors already discussed, the *number of practice periods* affects the appearance of the plateau. The absence of a plateau may mean that practice has not been carried to the limit of the individual's capacity to improve. The failure to do so in the industrial situation entails a waste of individual productive capacity and constitutes a source of dissatisfaction on the part of workers deprived of the opportunity of increasing earnings through increased production. This problem will be taken up again in the section dealing with length of the training period.

Among other factors which may account for arrested progress is the *failure to apply analysis* in promoting the integrations necessary for the further development of skill.[37] This appears, for example, in the work of accountants who had attained a high rate of speed in adding, but who succeeded in increasing enormously the speed of their work by a thoughtful analysis and practice leading to the simultaneous addition of three parallel columns. *Lack of confidence,* undue haste, are other items to be considered in the study of training techniques designed to eliminate incidental plateaus not essential in learning and final settlement at the highest possible level.

[37] T. H. Pear, *op. cit.*, pp. 54–55.

XX. TRAINING METHODS

WHOLE- VERSUS PART-METHOD IN THE ACQUISITION OF SKILL

A major problem in the acquisition of skill in industry is whether to train a worker in the entire process at one time or to confine training to one element of the operation until this is learned, proceeding then to others until the complete process is learned.[1] The continuous repetition of an entire operation until the desired stage of mastery or level of skill is attained is known as the *whole-method* of learning.[2] The successive mastery of sections of material or smaller units of a task is designated as the *part-method* of learning.

An example of the latter method is found in procedures employed by Berling[3] in training apprentices in the metal industry. The procedure in this training program is to isolate the various operations required in this trade and to give practice separately on each through the use of specially constructed apparatus. So, for example, the apprentice is instructed in the use of the file by practicing filing on a special device that provides a graphic record of the direction of movement, the pressure exerted and the "levelness" obtained. The character of the device used for this purpose is shown on Figure 55. Levelness is recorded by the stylus marked "a"; pressure by "b"; and movement in filing by stylus "c." By comparing the record obtained in the course of each practice period with curves showing the required standards of proficiency, the apprentice is able to determine the factor to be stressed in further practice and is motivated to improved performance. The improvement obtained in this way is indicated in Figure 55 showing the curves for pressure and levelness at the beginning of practice and at the end of 32 hours of practice with the filing apparatus.

Similar procedures and specially constructed apparatus are used in teaching the apprentice to use micrometers, calipers, and other measuring tools; in teaching him to use the hammer and other tools correctly; etc. Accuracy in hammering, for example, is developed by supplying the apprentice with a lead block and a pointed hammer.[4] The apprentice first practices by denting the surface of the block with his ham-

[1] H. C. Link, *Education and Industry*, New York, 1923, p. 134.

[2] L. A. Pechstein, "Whole versus Part Methods of Learning, *Psych. Mon.* No. 99, (1917), pp. 80.

[3] G. Berling, "Planmässiges Einführung des Menchen in den Industriellen Arbeitsabslauf," *Ind. Psychot.*, 3 (1926), pp. 79–86.

[4] R. Bolt, "Anlernverfahren für das Arbeiten mit kleinen Hammern," *Ind. Psychot.*, 3 (1926), pp. 193–211.

mer. He then attempts to strike the same hole twice. At a later stage of training he is placed before a block covered with a sheet of paper containing 15 small squares, with a dot in the center of each square. The apprentice is instructed to strike each dot twice with the point of

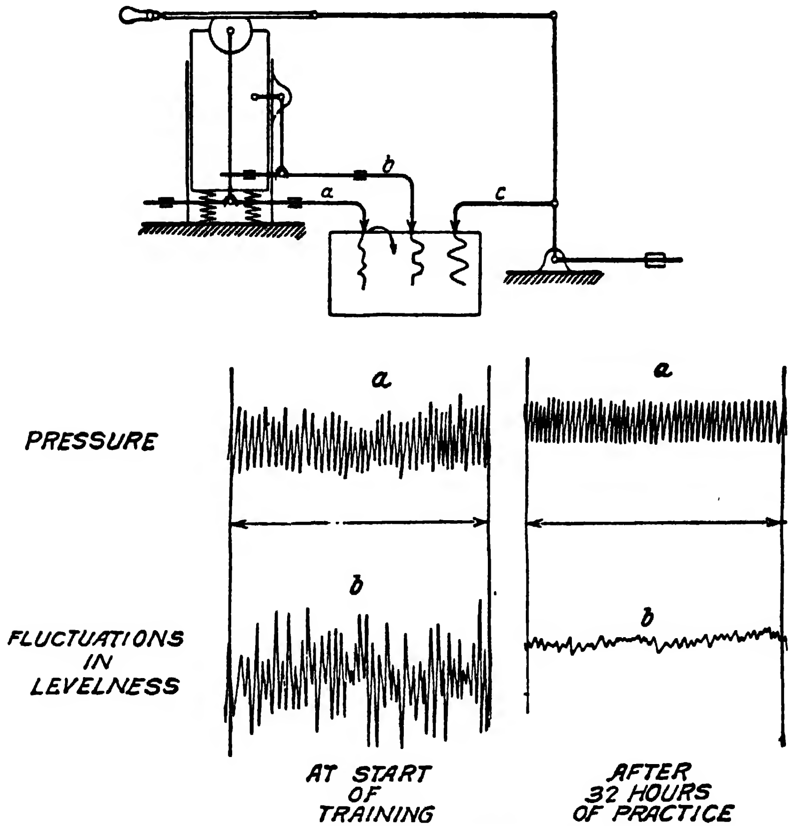


FIGURE 55. *Apparatus for Practice in Use of File*
and
Record of Improvement with Practice
(After Berling)

the hammer. The distances of the points struck from the central dot are measured and curves constructed showing the average of these distances. In this case again the apprentice is informed of his daily progress as a means of helping him to correct errors and motivating him to improved performance. Only after the required level of efficiency has been attained on each operation is the apprentice given an opportunity to employ and co-ordinate these skills by work on the kind

of material ordinarily used by the machinist and on the whole task of transforming this material into a useful object or tool.

Instruction in crane operation furnishes another illustration of the application of the part-method in industrial training. Apprentices for this occupation are trained by Berling [5] on a practice crane. They start by practicing, without electric current, the operation of the controller. This is followed by practice with the various levers employed in lifting. The apprentice is then given practice in actually moving the crane. Practice is also given on such individual items of operation as gauging the distance of the object to be lifted, controlling the rate of movement of the crane, determining braking distances, and in other simple units of the job. Only after a high level of efficiency is achieved in each of these simpler operations is the operator given practice in the whole task, involving an integration of lifting, conveying, and placing in another spot material of the type that is ordinarily handled by the crane operator.

The exponents of this part-method of industrial training contend that it serves to reduce the training time; decreases the amount of spoiled work; raises the level of productive efficiency and in other ways furthers the interests of sound training. In general, the procedure in such training is to start with the simpler and to proceed to the more complex operations of the task.

An example of the unmodified whole-method of training is to be found in the procedure usually adopted in training motormen, described in Chapter XIX. In this case, on the very first day of training, or at the latest on the second day, the apprentice is actually placed on a moving car and required to control its movement, to open and close doors and to co-ordinate these responses with the observation of the street under the very conditions which will apply after he has completed his training course. The theory underlying this program is that the best results in training can be achieved if the entire operation is repeated again and again until the necessary level of proficiency in carrying through the co-ordinated task is attained. The whole-method is also exemplified in that system of apprentice machinist training which requires the apprentice to work on the entire process of machining, boring, hammering, filing, and measuring a simple tool or object. In this training system the complexity of the task is increased with the years of apprenticeship, but each task at each level is performed in its entirety and may involve all of the constituent skills.

Sometimes a compromise between the whole and part-method of training is employed. In training motormen Tramm [6] has followed the procedure of setting up a bank of controllers and associated apparatus involved in street car operation and has required apprentices to prac-

tice the co-ordinated movements as a preliminary to operating under street conditions. Only after the fundamental responses are well fixed, under the observation of a competent instructor, is the apprentice permitted to operate under street conditions, combining at that time the habits of response established in the laboratory with the conditions of attention and perception occurring in the course of actual operation. Similar procedures have been employed by Schwarze [7] in training railroad employees. The author [8] has also employed a modified whole-part method in an apprentice machinist training program, the chief feature of which is progress from work on simple projects, requiring only *cutting* and *filing* to more and more complex projects in connection with which additional operations, such as *planing, milling, screw cutting,* are successively introduced as an aid in development of necessary skills in this type of work.

The relative values of the part and whole-method of training have been studied in laboratory investigations which have furnished results of significance in gauging the effectiveness of each method in training industrial workers. In so far as *verbal* learning is concerned, the whole-method is generally found to be most advantageous.[9] The disadvantages of the part method increase with increased sub-division of the material. These conclusions follow from many studies, dating back to the very early investigation in this field by Steffens,[10] and including classic investigations by Kuhlmann,[11] Meumann,[12] Pyle,[13] and others. The superiority of the whole over the part-method in verbal learning is manifested by fewer repetitions required for learning, more correct formulation of associations, and more accurate attention over a longer period.

The question of the whole versus the part-method in *motor* learning was entirely disregarded by psychologists until the middle of the second decade of the present century.[14] This problem was first investigated [15] by Pechstein,[16] who undertook to determine whether the "whole" or "part" findings in rote and logical verbal learning hold for sensory-motor, adaptive problems both in the case of animals and in

humans, in order to evaluate the factors responsible for economy or waste in these methods of learning.

As apparatus for the experiment Pechstein employed a maze of special design. Similar mazes were used for white rats and for humans. The human subjects included 53 men and 59 women students in a class of introductory psychology. For both the animal and human subjects constant conditions of lighting, furniture arrangement, quietness, and the hour at which the maze was run were maintained. Experimental procedure was similar for human subjects and rats, each having 1 run per day in the maze for 4 days, followed by 2 runs in succession per day until 4 out of 5 successive runs were without errors. The rat was required to run the maze, whereas the human subject traced the maze with a stylus, the hand and maze being concealed from sight by a black hood.

A careful analysis of findings led Pechstein to conclude that modified part-methods are superior to the whole-method in maze learning, but that the purely part-method remains inferior in the case of humans regardless of the measuring criteria. This results from the fact that modified part learning utilizes the inherent advantages of part learning in the form of transfer of factors and avoids diminishing returns due to the excessive length of the motor problem.[17]

In addition to examining the influence of the whole and part-method of learning Pechstein also investigated the advantages of concentrated or massed as against distributed learning. In this he followed the lead of earlier experiments by Browning, Brown, and Washburn [18] and by Murphy,[19] who found distributed learning to be of advantage in a series of motor acts. Thirty-six human subjects were employed in each part of the experiment, each group being taught maze A by one of the methods of the whole, modified part, and purely part training used in the original experiments. The results showed the concentration of learning to be highly unfavorable when the whole-method of learning is used. In contrast the part-method of learning becomes among the best of all available methods of learning when learning is concentrated. This is also true to a smaller extent of the modified part-methods.

Illustrative of more recent laboratory investigations of this problem, having a more direct bearing on industrial training, is a study by Beeby,[20] who employed as apparatus a flat wooden base 55 x 27 cms. on which are pivoted in a horizontal position two wooden discs so attached that they can be revolved about their centers and locked in any position. Geometric figures of differing shapes and sizes, cut in

[17] *Ibid.*, p. 58.

[18] M. Browning, D. E. Brown, and M. F. Washburn, "The Effect of the Interval Between Repetitions on the Speed of Learning a Series of Movements," *Amer. J. Psych.*, 24 (1913), pp. 580–583.

[19] H. H. Murphy, "Distribution of Practice Periods in Learning," *J. Ed. Psych.*, 7 (1916), pp. 150–162.

[20] C. E. Beeby, *op. cit.*

outline from $\frac{1}{16}$ inch brass, can be attached to this base. In this experiment square plates were attached to the base, and the subject required to follow around the brass squares with metal styluses in such a way as to avoid breaking the contact between the styluses and the figure. Breaks, automatically recorded, constituted errors. In following around the squares the hands were moved in counter-clockwise direction.

The investigator undertook to measure the effectiveness of training by wholes and parts by the method of *simultaneous combination*, where the right hand and left hand, having been separately trained in tracing squares on the right and left sides of the apparatus respectively, were forced to perform these movements together, and by *simultaneous division* in which the hands, having been trained to perform the movements together, were required to perform these movements separately.

The subjects were advanced students of psychology, divided into 2 main groups. Group A started with a single hand process (*simultaneous combination*) and returned to the single handed tracing after under going double handed practice. Group B started with the double hand practice (*simultaneous division*) and returned to the double handed tracing after an intervening period of practice with each of the single hands. Subjects were blindfolded during the course of the experiments which were supplemented by a control experiment with vision.

Each of the main groups was sub-divided into smaller groups; *first* in order to determine the extent of transfer of skill from practiced right hand to un-practiced left hand and vice versa. In addition, the facts that each subject's performance required 2 sittings, each lasting from 2 to 3 hours, and that the 2 sittings were given with a lapse of 7 days made it necessary to set up a control group where the lapse of time was the only factor intervening between the first and third parts.

The results show that a *combination of relatively simple movements into a movement-whole results in a loss of efficiency*. Likewise the division of a movement-whole into its simultaneous constituents results in a loss of efficiency. An additional loss of efficiency marks the return to the original performance after either division or combination. From these findings the author concludes that movements are essentially different according as they are performed in combination or in isolation. An initial positive transfer occurs between the single and double operations and between right and left hand action which, with further practice, is converted into a negative transfer or interference [21] that actually constitutes a disadvantage for those who come to it again after a previous practice period on the other. Transfer is general rather than specific in character.

An analysis of his findings leads Beeby to conclude that the "whole" method of learning a muscular habit is preferable to the "part" method. The author points to the need of further research in order to de-

[21] See pages 423–28.

termine the degree of complexity of movement at which the disadvantages of the "whole" method outweight its advantages. Of interest in Beeby's findings is an incidental observation, by the method of introspection, which indicates that, in so far as consciousness is concerned, there are two main stages in the progress of acquiring skill: (a) the *learning stage,* in which the concentration of attention on the task helps to crystallize the activity, and (b) the *expert stage,* in which consciousness is withdrawn from the task, becomes *non-focalized* and has no further influence on the efficiency of learning.

The final test of the relative effectiveness of the whole and part-methods in training workers must be made in the industrial situation. Laboratory studies can contribute much, particularly in the way of an analysis of underlying factors, but the difference in conditions in the plant, as compared with the laboratory, make necessary an evaluation of the methods under plant conditions. Such an evaluation has been attempted by Finck.[22] The subjects of this investigation were 36 apprentices, approximately 15 years of age, employed by the General Electric Company of Germany, half of whom had been employed for a period of one month, and the other half for a period of 7 months. The 36 apprentices were divided into two groups, equal from point of view of length of service. Each group was given the same preliminary instruction in the performance of 3 simple tasks, the *first* involving visual estimation of distance between 2 points; the *second* involving motor coordination in bolting spheres to a metal plate; the *third,* requiring the subject to attach iron bars by means of 2 bolts to a metal plate. The apprentices in the first group were required to repeat each of the three tasks, in order, 8 times—following in each repetition the sequence of operations necessary to complete the task before going on to the next. In the case of the second group each of the 3 tasks were split into its constituent operations and the apprentice repeated each operation 8 times, but was not required to complete any task as a whole. At the end of the experiment each group had practiced each operation 8 times. The magnitude of the error represented the criterion of performance on the first task. The time taken to place and remove each sphere served as a measure of efficiency on the second task. The number of spheres dropped was also considered. The time required to attach the iron bar was used as the measure of progress in the third task.

In the case of the task involving visual estimation, the performance of the group employing the part-method in practice was found to be superior to that employing the whole-method. Superiority is shown in the lower average time required to complete the operation and in the fact that the practice curve reaches a plateau on the sixth trial, while average performance time is higher and there are no signs of a plateau by the end of the eighth trial in the case of practice by the whole-

[22] E. Finck, "Anlernung im Ganzverfahren und im Teilverfahren, *Ind. Psychot.*, 3 (1926), pp. 212–16.

method. Employing similar criteria the whole-method is found to be slightly superior in the second task. In the third task the difference again favors the part-method. In no case is the actual difference in time great. No certain difference in quality of work is found between the two groups. However, the investigator concludes that the part-method, in which the individual operations of a whole task are repeated separately in learning the task, is superior to the form of training in which the apprentice performs the whole task and repeats it again and again until the desired level of efficiency is attained.

In considering these findings and conclusions it must be recognized, as the investigator himself states, that the three whole tasks employed in this investigation are not bound up with each other in a natural sequence as the larger elements of a job in the industrial situation. Moreover, findings are far from unequivocal, and can perhaps more fairly be interpreted as showing no significant difference between the whole and part-methods (under the conditions of the experiments) than as favoring the whole-method.

An investigation by Krueger [23] represents another approach in the investigation of the whole-part problem in industrial training. Twenty-three apprentice machinists were divided into 3 groups on the basis of a selection examination; the best being placed in Group I and the worst in Group III. All 3 groups followed a systematic course of training. Group II was, in addition, given special practice on the use of the file in the course of work in the plant. Group III was given an opportunity to practice the use of the file on a special device of the type described above. Each group was then assigned a test problem in filing. An examination of the products showed the second and third groups to be practically identical. From this the author concludes that the two methods of instruction are essentially of equal value.

In contrast to conclusions from the studies by Finck [24] and by Krueger [25] is the evidence on the superiority of the whole-method presented by Dilger [26] who also compared two methods of instruction in the use of the file. The subjects of the experiment included 2 groups of workers, numbering 15 and 14 respectively, alike from the viewpoint of ability as measured on selection tests. Each group was given preliminary instruction on how to hold the file, on body and arm position in filing, etc. The first group then practiced filing for ½ hour a day, 2 times a day for a period of 16 days, in producing even flat surfaces on metal, the accuracy of the work being checked frequently, by the worker, with suitable measuring devices. Practice under these conditions, on a vise, resembles work done under the ordinary conditions of

[23] G. Krueger, "Versuche mit verschiedenen Ausbildungsverfahren bei Maschinenschlosserlehrlingen," *Psychot. Z.*, 4 (1929), pp. 144–58.

[24] E. Finck, *op. cit.*

[25] G. Krueger, *op. cit.*

[26] J. Dilger, "Feilübungen am Schraubstock und am Anlergerät," *Ind. Psychot.*, 5 (1929), pp. 369–74.

the plant, filing being alternated with measuring in the "whole" task of preparing metal pieces of suitable thickness with flat surfaces free from irregularities. The second group practiced filing on a special apparatus, checking performance by observation of graphic records and emphasizing, in each practice period pressure, movement or levelness, upon the basis of these observations. Both groups spent the remainder of each practice day on light physical work in the plant.

At the end of 16 days each worker was given 2 work problems. On the first, a preliminary test of quantity-production, he was instructed to file away from the side of a cube as much material as possible in a 2 hour period. In the main problem a dent was made on each of 5 sides of a cube and the worker required to file off the surface until the mark could no longer be seen. From 3 to 8 hours were required for this work. The finished cubes were divided into 5 groups by 2 judges, partly on the basis of measurement. Whereas the work of 10 of the 14 workers who had practiced on the vise were rated in the highest 3 groups, only 7 of the 15 workers who had used the special practice device obtained these ratings. A control experiment, involving supplementary practice, shows that the difference between the two groups was produced by the superiority of the traditional method of training involving practice on the whole task under plant conditions. On the basis of these findings Dilger [27] questions the desirability of using devices providing opportunity for practice on elements of the task under artificial conditions. The best training program, according to this investigator, is that which shortly after enrollment gives the worker practical tasks of progressive difficulty to be done under direct supervision, supplemented from time to time by test problems.

When the findings of laboratory and plant studies are combined, there appears sufficient reason for questioning the usefulness of the part-method in industry. In the artificial isolation of the elements of a task, the pattern or integration of responses is distorted,[28] and the objective of more rapidly stabilizing this pattern at a high performance level cannot be achieved. "To teach a knowledge of the *parts* first, by fixing consciousness separately and rigidly upon them, and to hope that the *whole* may eventually be built up out of the parts, is to confess complete disbelief in natural methods of learning." [29] A modified whole-method may be preferable to the whole-method where the task is very complex but even in such instances, as Link [30] has pointed out, "it is best to give an individual an idea of the process as a whole, even if it is only a superficial idea." After this, if necessary, the task can be split into "natural subdivision" each subdivision being kept, however,

[27] J. Dilger, *op. cit.*, p. 374.
[28] H. Rupp, "Psychologische Grundlagen der Anlernung," *Psychot., Z,* 2 (1927), pp. 42–61.
[29] F. Watts, *An Introduction to the Psychological Problems of Industry,* London, 1921, p. 64.
[30] H. C. Link, *op. cit.*, pp. 134–35.

as large as possible in order to take advantage of the associations between movements inherent in the task as a whole. The exact nature of the subdivision will depend upon the process involved, each requiring careful analysis in order to make most effective use of the whole or modified whole-method in training workers.

THE ANALYSIS OF PRACTICE CURVES

(a) *The Length of the Training Period*

The length of the training period will naturally differ with different kinds of work depending upon the length of the task and the complexity of the operations involved. The length of the optimal training period is determined by that point beyond which further training will produce no significant increase in rate of work or further improvement in quality of work. Additional practice may result in additional skill but this skill will not be acquired at a rate sufficient to justify further training.[31] Ordinarily, for example, the greater part of the skill of a typist is acquired in the course of several months of training. The typist might increase her skill for a period of several years, but the cost of developing this increased skill would be entirely out of proportion to the amount of increased skill that could be developed by continued practice. Formal training in this skill should only be continued during that period necessary to meet the ordinary standards of production. The same principle applies to training in industrial work.

The length of the training period will depend, in part, upon the individual and, in part, upon the act of skill under consideration. For the *individual* the length of this training period will naturally be determined by the physiological limits of his "trainability" or, in other words, the limits of his capacity to improve the co-ordinations required for the work. For a group of workers that has been carefully chosen, which is relatively *homogeneous* from the viewpoint of aptitude for the work, working under similar conditions, the length of the training period can be expected to be approximately the same. The use of practice curves in recording the progress of training makes it possible to determine the optimal length of the training period both for the task and for the individual. *Assuming that incentives and other conditions of work remain constant,* and *that the most suitable training methods have been employed,* it is uneconomical to continue training beyond the point at which the learning curve flattens out into a plateau. By employing this criterion, it is possible to judge when, for all practical purposes, further formal practice may be dispensed with.

The dependence of the length of the optimal training period on fac-

[31] E. S. Robinson, "Factors Affecting Human Efficiency," *Ann. Amer. Acad. Pol. Soc. Sci.*, 110 (1923), pp. 101–102.

tory jobs upon the character of the work appears in a study by Meyer,[32] who examined the practice curves of 3 workers on 3 machine operations. In the case of operation No. 3, the curves show that at the end of 30 days production time per unit is decreased to approximately 65 per cent of the time taken when work was first started and that there is no further decrease in unit production time after this period of work. In the case of operation No. 2, the curve shows no definite signs of approaching a plateau until after approximately 40 days of work and does not reach a consistent level until approximately after 50 days of work, when production time is decreased to approximately 60 per cent of that required at the beginning of the work period. Operation No. 1, involving more complex machine work, shows rapid decrease in unit production time. At the end of approximately 45 days, when observations on this work were discontinued, there is no sign that the plateau has been reached in spite of the fact that the time required for production per unit has been decreased to approximately 38 per cent of that taken when practice was started.

Meyer's observations lead him to conclude that the gain in time through practice bears a direct relation to the initial time required for unit production and to the extent of participation of the worker, in contrast to the machine, in turning out the work. This conclusion is supported by Engel,[33] who examined the relationship between amount of gain from practice and the length of the training period in relation to production time per unit during the first day of work on a variety of factory jobs. The production time per unit during the first day of work is identified by Engel as *base unit production time*. An analysis of findings revealed a relationship between this time and the length of the training period which are expressed in the following principles:

1. The relative gain from practice bears a direct relationship to the value of the base unit production time. In other words, larger base unit production times are associated with relatively greater gain from practice.
2. The relative amount of gain decreases with increasing practice.
3. The base unit production time depends upon the complexity of the task and upon the relative participation of the machine and of the human element in limiting the rate of production.

The results suggest the possibility of empirically establishing the optimal length of the training period for each task by an experimental analysis of production during the early period of training and by an examination of gain from practice as shown on suitably plotted practice curves.

Since gain from continued practice is not constant for all opera-

tions, and at all stages of practice, it is evident that the training period may not only be too short, but may actually be made too long to provide the maximum benefits from training. Associated with possible loss from *over-training* is the question of the length of each training period, or the distribution of the total amount of time to be spent in training. The practical implications of the problem are shown in an experiment by Henshaw and Holman.[34] Three groups of 30 subjects were employed on chain assembling for a period of 80 minutes each morning. During the afternoon Group I spent an additional 80 minutes in assembling chains; Group II spent the time in cartridge filling and Group III remained unemployed. After a fortnight of work the performance of the three groups on chain assembling was found to be practically identical in spite of the fact that Group I had actually twice as much practice as Groups II and III. After a lapse of a few months 5 subjects from Groups II and III were again employed at chain assembling for 80 minutes each morning for a fortnight. After an initial drop, due to the interruption of practice, this group continued to improve at the same rate as during the earlier experiment, indicating that maximum improvement had not been reached in the first fortnight, and that the failure of the doubling of the practice in the case of Group I to effect additional improvement was not due to the flattening of the practice curves. The rate of output of the second group of 5 subjects was shown to be considerably above that of Group I after they had had the same amount of training.

The results show that the increase of the daily training period beyond a certain length, in the case of this task, had no beneficial effect on learning, inasmuch as the extra 80 minutes of training in the afternoon resulted in no additional improvement. Such results, as well as those obtained by Pechstein [35] and others on the effects of *distributed* and *concentrated* learning, suggest the importance of determining the *optimal arrangement,* as well as the optimal length of training, for every industrial operation.

(*b*) *The Control of Individual Progress in Training*

Practice curves can be used not only to determine the optimal length of the training period for each task, but in promoting the effectiveness of individual instruction. Such curves constitute exact records of individual progress. Guidance at plateau levels may do much to promote further gain from practice and to prevent stabilization of production at a low level of efficiency. The effect upon the individual of changes in methods of work, of shifts of attention, of fluctuations in intrinsic or extrinsic motivation can be readily observed and steps taken to overcome these disturbing conditions. In addition, there is evidence which

[34] E. M. Henshaw and P. G. Holman, "A Note on Over-Training," *Brit. J. Psych.,* 20 (1930), pp. 333–335.

[35] L. A. Pechstein, *op. cit.*

suggests that the progress of a worker at an advanced period of training can be predicted from a study of the practice curve obtained during the early part of the training period.[36] "If a subject's learning constant is known for a given type of learning material, and if the complexity of a certain task has been determined in other experiments, the subject's learning curve on this task can be predicted for constant *conditions of motivation.*" [37]

Unfortunately, conditions of motivation often fail to remain constant and other conditions occur which tend to interfere with the smooth progress of learning and make ineffective, in individual cases, the general equations which have been formulated for making such predictions. These factors, and the benefits to be derived from more detailed study of gain with practice, make it necessary to resort to a detailed qualitative analysis of records of progress as a means of determining the effect of training and of promoting individual efficiency and adjustment during the training period.[38] The importance of such an analysis is apparent when consideration is given to the complex character of trainability; to the enormous number of factors influencing

[36] D. H. Kowarski, L. Kowarski and M. Francois, "Contributions à l'Étude de l'apprentissage," *L'Annee Psych.*, 31 (1930), pp. 192–216. H. Heinis, "La Loi de L'Éducabilité," *Comptes-Rendus, Vme Conference Internationale de Psychotechnique,* Utrecht, (1928), pp 207-211.

[37] Thurstone presents an equation useful for this purpose in rote learning. The procedure is suggestive with respect to other types of learning. A learning test that is homogeneous (elements of equal complexity) gives a symmetrical S-shaped learning curve which satisfies the rational equation.

$$\frac{2p-1}{\sqrt{p-p^2}} = \frac{kt}{\sqrt{m}} + z_o$$

in which p = proportion of successful acts in unit time
t practice time
k learning constant of the subject. It is the average number of errors eliminated in each exposure.
m complexity of the task
z_o value of z when $p = p_o$. It may be regarded as a constant.
p_o value of p when $t = o$.

Furthermore the relation between length of a homogeneous task and learning time required by the individual is described approximately by the rational equation

T total learning time measured to any arbitrarily stipulated degree of perfection
n length of the task
k subject's learning constant
c a constant depending on the complexity of the task and the degree of perfection required
a adaptation constant of the subject.

The relation between length of a homogeneous task and the number of repetitions required to learn it is described approximately by the following rational equation

$$R = \frac{c}{k}\sqrt{n-a}$$

in which R = number of repetitions required for complete learning."

See L. L. Thurstone, "The Learning Function," *Jour. of Gen. Psych.*, 3 (1930), pp. 469–91.

[38] Such an analysis, as has been suggested in the discussion of "analogous" and "analytic" tests, may serve not only as a criterion of individual progress in training, but also as a direct measure of individual aptitude for the task. See Chapter XII, pages 225–44.

the acquisition of skill; to the effect of degree and persistence of effort during training, or zeal and determination, of the difficulty of combating boredom, annoyance, discouragement, etc.[39]

The desirability of an analytic study of records of progress, covering short periods of time, as well as of practice curves plotted to show daily or weekly progress, has been particularly stressed by Argelander [40] and by Poppelreuter.[41] The latter points out, for example, that there are apprentices who first work slowly and accurately, but who, after a lapse of time, show a characteristic trend in the direction of fast but inaccurate work. On the other hand, he finds apprentices who, although appearing to be unsatisfactory workers at first, slowly, but with a *high*

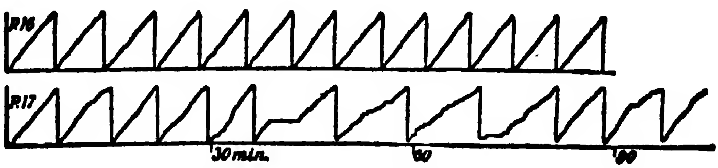


FIGURE 56 A. *Individual Practice Curves*

(*After Poppelreuter*)

degree of certainty, develop into satisfactory workers from the viewpoints both of quality and quantity of production.

Poppelreuter has employed the *arbeitsschauuhr,* making available graphic records of rate of production, of voluntary rest pauses, etc., as an aid in analyzing the progress of the worker during training. Figure 56A, shows the work records of two apprentices engaged on a laboratory task involving heavy work of a type that a machinist operating an hydraulic hammer may be called upon to perform. The apparatus employed for this type of work is shown in Figure 56B. The subject is required to punch holes on a narrow roll of paper with a punching device weighing 30 pounds. After the hole has been punched the weight, raised by both hands, is lowered to its frame, while the subject draws out the paper in preparation for the next punch. The subject is instructed to set his own pace, to pause whenever he chooses, to sit down whenever he chooses, etc., and an accurate record is automatically kept of his work. It can be observed that the production of the two subjects, P-16 and P-17, is at first about equal. As a matter of fact, the former does not do as well as the latter at first, because he performs the work of lifting the weight to punch the moving band with less regularity. However, with continued practice in the work, there develops

greater and greater difference between P-16 and P-17, with the latter exhibiting a consistently irregular and lowered production, characterized by many pauses in work. These characteristics appear only after he has been given an opportunity to engage in the work for a period of time. In this case, their existence could not have been foreseen in the early part of the work period. Moreover, the exact nature of the disturbing factor would be concealed in a mathematical treatment of the practice curve. As records for longer periods of time are studied, char-

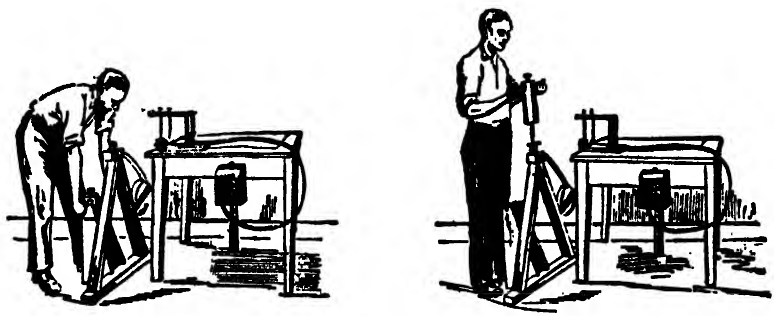


FIGURE 56 B. *Apparatus Employed in Studying Practice Curves (After Poppelreuter)*

acteristic work traits, of such great importance in training and in final adjustment are revealed. Although the curves shown in Figure 56A represent tasks performed in the laboratory rather than in industry, they are characteristic of the type of curves which can be found if the progress of apprentices on the job is followed. Their study makes it possible, in many cases, to correct conditions interfering with gain from practice and with production and in others, when such correction is not possible, to provide for the re-adjustment of the employee in another form of work.

The possibilities of this procedure as an aid in promoting the acquisition of many diverse forms of skill are illustrated in its use by Nier [42] in the instruction of street car motormen. In this instance a moving picture is employed as a stimulus for response on controls whose movements are recorded on a band moving in synchronism with the film (Plate V and Figure 41): The graphic record of time, form and variations of movement involved in starting, stopping, etc., serves not only as a measure of progress with instruction, but as a basis for the qualitative analysis and correction of operating defects not revealed by any less refined method of studying practice effects.

[42] M. Nier, "Der Mensch als Wirtschaftsfaktor im Verkehrsbetrieb," *Ind. Psychot.*, 8 (1931), pp. 33–51; 74–96.

TRANSFER OF TRAINING

Allied to the problem of the whole and part-method in training is the question of whether practice on one form of work is of advantage in enabling the worker to perform better other kinds of work. Until recently educational practices were formulated on the belief that an increase in efficiency in one activity is accompanied by an increase in the power to perform other similar activities. This belief in the *transfer of training* assumed the existence of "general faculties" or "unitary powers" of memory, observation, judgment, motor ability, etc., each of which was developed through exercise with any difficult task involving that faculty.[43] The dominant positions of Latin and mathematics in the curriculum of the secondary school, maintained until the beginning of the present century, reflects the faith in the value of such subjects in stimulating the development of the general faculties of memory and reasoning. Vocational courses were introduced into the curriculum in part because of the belief that manipulation with tools improves the motor ability of the school boy and thereby makes him more fit for entry into a trade.

In the industrial situation the use of training material reproducing in miniature the task to be performed by the worker reflects a confidence in the transfer of the effects of training from one task to another task. Such material is illustrated in the training program developed by Schuschakow and Perewersew [44] who used a miniature model of a locomotive and a train of cars in instructing railroad engineers in the proper application of brakes for the purpose of avoiding accidents and in the control of speed to overcome excessive jolting. In training bill sorters an attempt has been made to facilitate improvement by a period of practice on the analagous task of sorting cards with different designs. The assumption in such training is that "the effect of training in any specific form of mental activity may be transfered to any other activity of the same form, although dealing with different materials." [45] The belief in transfer assumes that quantitative and qualitative changes in one ability result from quantitative and qualitative changes in another as the result of practice.[46]

The possibility of transfer on a task resembling industrial work has been investigated by Langdon and Yates.[47] The task employed was that of assembling bicycle chains on the apparatus illustrated in Figure 76. The subject is seated in front of a table on which is fixed a circular turn-table carrying spindles on which links are placed. As each spindle

comes before the subject he removes it from the turn-table, dropping the link into a box at his right hand. At the same time a link is taken from a box at his left hand, placed on the spindle, which is re-inserted in the turn-table and the latter turned so as to bring the next spindle into position for the repetition of the operation. A Veeder counter is employed to record automatically the number of links handled at each period of work.

Thirty-two subjects were trained in this work by spending 80 minutes on this task both morning and afternoon for a period of 2 weeks. A period of 10 minutes rest was alternated with each period of 10 minutes work during the progress of the investigation. Before training was commenced the subject was tested on a series of performances later employed in measuring the incidence of transfer. These performances included:

(1) *Match insertion.*
(2) *Placing matches in a box.*
(3) *Placing rings on a rod.*
(4) *Threading links.*
(5) *Arm movement.*
(6) *Moede's impulse meter.*
(7) *Steadiness tests.*
(8) *Mental arithmetic.*
(9) *Cancellation test.*

This series of tests was given to each subject prior to practice on the chain assembly, at the end of the first week and at the end of the second week of training. The same tests were given, also in the same order and at the same intervals, to 28 subjects who had received no training, constituting a control group. Subjects of the experiment were all boys between 15 and 18 years of age, who were paid a minimum wage of 12 shillings per week and who, in addition, received a bonus depending upon the degree of improvement on the performance. On the day on which the transfer tests were given the improvement in these was included as a basis in calculating the bonus, so that motivation was constant from test to test. Members of the control group were paid on the same basis.

An analysis of the results showed no greater improvement on the part of the experimental group on the tests of manual dexterity than appeared in the control group, the members of which had received no opportunity for practice on the chain assembly operation. On most of the performances both the experimental group and the control group showed improvement in successive performance, particularly in comparison with the first and third performance on the transfer test. However, in no case was the difference between the trained and controlled groups with respect to improvements in the third as compared with the first trial on the test significant—significance being expressed

in terms of the ratio between the difference in means and the standard deviation of the difference. In other words, the brief practice due to each test itself is more effective in producing improvement in that performance than is intensive training in an analagous performance. The results of this experiment support the view that training in manual dexterity is specific rather than general.

This experiment was followed by an investigation designed to determine the effect of intensive training in estimating the size of steel balls lying within a given range on estimation of a similar series of balls lying outside of this range. Balls ranging in diameter from $^{16}/_{64}''$ to $^{7}/_{64}''$ by differences of $^{1}/_{64}''$ were employed. The balls were lifted on a spoon and the diameter estimated visually. Conditions of illumination

TABLE 54

Subjects	*Initial score*	*In % improvement* 1–2	2–3	1–3
Trained, A	265	104.6	7.4	119.1
Control, c	252	265.2	—16.9	203.6
Control, k	278	86.6	34.2	150.5
Trained, C	113	97.1	13.3	123.3
Control, d	130	88.4	18.9	124.1
Trained, D	132	39.2	— 3.9	33.8
Control, n	137	95.7	84.2	260.5
Trained, E	74	— 30.8	7.1	25.9
Control, b	76	13.4	21.8	38.2
Trained, F	156	5.3	23.1	29.6
Control, r	164	60.8	17.2	88.5

(After Langdon and Yates)

were kept constant. One hundred balls, 10 in each series were presented. The time taken for this, 10 minutes, was followed by a rest period of 10 minutes. Conditions of work and payment were the same as those in the first experiment. The material for the transfer test consisted of 100 very much larger balls, 10 of each size, ranging in diameter from $1''$ to $^{23}/_{32}''$ by differences of $^{1}/_{32}''$. Six subjects were included in an experimental group, trained for a period of 2 weeks and 18 in a control group not trained and given the transfer tests under identical conditions.

The results reveal no superiority of the trained over the control group. A comparison between the trained and un-trained subjects with approximately the same initial score, is shown in Table 54. It can be seen that in each case it has been possible to find a member of the control group who showed a greater improvement in test 3 over test 1 than did a comparable member of the trained group. The evidence from this study is that in the case of visual discrimination, as in

the case of manual dexterity, the effect of practice is specific to the operation.

From the viewpoint of practical implications this means that training in industry should be confined to the specific operations of the job. There can be no profit in attempting to teach workers to sort ball bearings by giving them practice in sorting geometric figures or other designs in the laboratory or in a "vestibule school." The operation of a motor vehicle cannot be successfully taught by practice on smaller electrical locomotives in order to improve accuracy in the estimation of speed and distance of a moving object even though capacity for this job may be determined by means of an analogous test in miniature form.

In contrast with the negative results of this experiment are findings favorable to transfer in early experiments by Coover and Angel [48] who found an increase in efficiency in certain aspects in typing on the part of 6 subjects trained for 40 days in rapid sorting of cards. Bair's [49] results on the effect of training in tapping rapidly on the typewriter a given series of exposed letters upon speed of tapping other series is also interpreted as indicating that one kind of practice helps in another kind.

The problem of transfer is very much confused by the failure to use a sufficient number of subjects and by the generally inadequate control of incentives and conditions of work in its investigation.[50] Summarizing the results of investigations it may fairly be stated that, in general, the amount of transfer of skill is small.[51] There is distinct evidence that the development of proficiency in one task can only satisfactorily be accomplished through the repeated performance of that task. Practice in other operations, involving the co-ordination of similar muscle groups in general, does not help in the acquisition of other skills and in some cases may actually interfer with their acquisition. In instances where transfer from one type of performance to another has been found, the transfer appears to follow largely from an analysis of methods; from the use of similar methods in training; and from the spread of mental attitude and of ideals set up during one task to another. The burden of evidence definitely supports the viewpoint of industrial psychologists such as Poppelreuter,[52] Sollier and Drabs,[53] and others, who firmly and repeatedly insist upon the im-

[48] J. E. Coover and F. Angell, "General Practice Effect of Special Exercise," *Amer. J. Psych.*, 18 (1907), pp. 227–40.

[49] J. H. Bair, "The Practice Curve," *Psych. Rev.*, Monog. Supp. No. 19, (1902).

[50] General aspects of the problem are reviewed by Whipple in a summary of investigations in this field. The interested reader is referred to that and to standard texts on educational psychology for further discussion of this problem. G. M. Whipple, "The Transfer of Training," *27th Year Book of the Nat'l Soc. Study of Ed.*, Bloomington, Ill. (1928), Part II, pp. 179–209.

[51] T. H. Pear, *op. cit.*, pp. 93–94.

[52] W. Poppelreuter, "Analyse der Erziehung zur Exaktheitsarbeit nach experimental-psychologischer Methode," *Zeitschr, f. angew. Psychologie,* 29 (1927).

[53] P. Sollier and J. Drabs, "La Prevision de la perfectabilité des aptitudes motrices," *Rev. de la Sci. du Trav.*, 2 (1929), pp. 26–40; 523–538.

portance of training in the task itself, under actual conditions of work, as the only certain method of promoting the integration of skills necessary for the successful performance of the task.

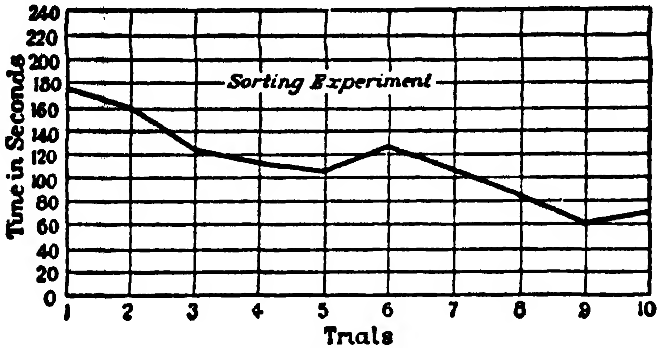
The study of transfer effect has indicated that under certain conditions the practice of similar tasks may induce a *negative transfer* or *interference* with the acquisition of skill. Evidence of this is found in the investigation of the whole-part method of training by Beeby, described on pages 412–14. The character of such interference is well illustrated in the classic card sorting experiment, in which the subject is required to sort as quickly as possible a set of 100 cards divided into 10 suits. The cards are so shuffled that in no case do cards of the same design come together. They are sorted to a board, approximately 15″ by 20″, placed before the subject, upon which the 10 designs of the suits have been drawn in two rows of 5 each. After the cards have been distributed 10 times, another order of designs is substituted for the one to which the cards have been sorted and the cards are again sorted 10 times.

Typical curves showing the time taken for the first and second series of 10 trials are shown in Figure 57. A comparison of Figures 57a and 57b shows clearly what generally takes place. During the first 3 trials with the changed arrangement of designs the time taken to sort the cards is longer than the time for the first 3 trials of sorting to the first arrangement. Practically every time this experiment is performed, the sorting time for the first 2 or 3 trials with the changed order is longer than the time in the first 2 or 3 trials of the first series. The time then generally decreases, as in the case of the 10 trials in the first series until at the end of the tenth trial in the second series the time may be less than for the tenth trial in the first series.

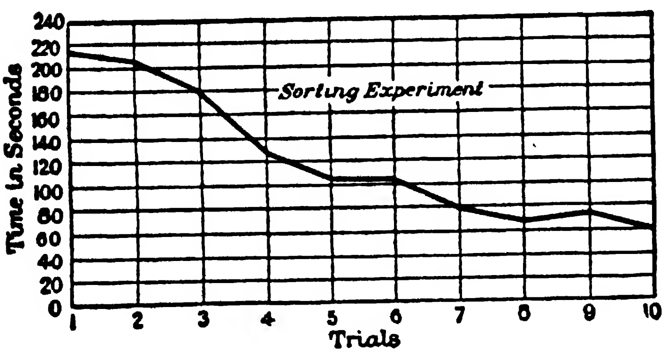
The increased time in the first few trials of the second series illustrates the effect of *negative* transfer. When opposing associations of movements are alternately or successively practiced, they have an interference effect upon each other, particularly during the early practice period. The formation of a habit is disturbed as a result of negative transfer, if another response, antagonistic to the one being learned, is practiced along with it. The stabilization of a habit of response may also be interfered with by an already established habit similar to that which is being learned. As has been pointed out in Chapter XIX, in learning to use a typewriter, it is easier for one who has never used a typewriter to learn to type correctly, i. e., with all ten fingers, than for one who has already typed, but incorrectly—that is, employing one or two fingers.

The chief weakness of the program for training motormen described on pages 395–97 is the opportunity which it allows for *negative transfer* or habit interference. The possibility of such negative transfer, combined with the evidence that the practice of similar movements has little if any positive value, further confirms the desirability of insist-

ing upon the repetition of only those movements which have been found most suitable for the task as a means of ensuring the achievement of the necessary level of skill in its performance. The importance of this



(a)



(b)

FIGURE 57. *Practice With the Sorting Test*

Figures on "time in seconds" given in the curves are not actual but hypothetical, approximating those generally obtained by averaging the results of a number of subjects.

(*After Viteles*)

will appear again in the discussion of accuracy vs. speed in the acquisition of skill, and in the discussion of the best methods of work.

TRAINING FOR SPEED AND ACCURACY IN WORK

One of the most important problems in training is whether attention should first be concentrated upon accuracy or first upon speed in teach-

ing skill. The general tendency, as Bartlett [54] points out, is to emphasize accuracy first on the assumption that it is easier to speed up than to correct inaccurate movements. Evidence that favors an emphasis upon quality of workmanship rather than upon quantity of production in the early part of a training program appears in an experiment described by Meyers,[55] in which 2 groups of 8 girls were required to make a pattern of 36 colored cubes. One group was instructed to work for speed, each girl being reminded at the beginning of each trial to speed up as much as possible. The other group was instructed to emphasize accuracy; being reminded at the beginning of each trial to take care that no errors were made. The speed group required less time than the accuracy group for forming the pattern in the first few days of the experiment, but at the same time developed a number of errors which became more and more fixed and finally provided an effective block against further increase in speed. The accuracy group over-took the speed group after approximately 20 days of work and at the end of 60 days was well in advance over the speed group, both from the viewpoint of rapidity as well as accuracy of performance. Results such as these suggest that if accuracy is stressed in early training not only will the quality of workmanship be better at the end of the training period, but that speed will also be greater than under conditions of learning where quantity of production is stressed early in the training period.

The results of a similar experiment in typewriting are cited in further evidence of this point of view. Two squads of 7 girls practiced 3 minutes for 36 consecutive days. At the end of this period the accuracy group showed little gain over the speed group. However, after 4 months without practice by either of the groups, each was required to copy for speed unfamiliar material for a period of 10 minutes. The speed group obtained an average of 383 words with 2.2 errors per 100 words, whereas the accuracy group wrote an average of 451 words with an average of 1.2 errors per 100 words.

The conclusions from these experiments are, in general, in accord with those formulated as a result of an earlier investigation of Stuart,[56] who, in training two groups of children to typewrite by speed and accuracy methods respectively, found that while the group that was trained in accuracy gradually improved in speed, the group that was trained in speed did not constantly improve in accuracy. Although, in the long run little difference was found between the 2 groups when the emphasis of each was changed, an analysis of the fingering movements and positions of the hands showed that, on the average, the movements of the accuracy group were considerably more "correct." This suggested that in this

[54] F. C. Bartlett, *Psychology and the Soldier*, Cambridge, England, 1927, pp. 69 ff.

[55] G. C. Meyers, "Speed versus Accuracy in the Development of Industrial Skill," *J. Pers. Res.*, 4 (1925), pp. 20–22.

[56] M. Stuart, "A Comparison of Speed with Accuracy in the Learning Process," *Brit. J. Psych.*, 12 (1921), pp. 289–300.

operation, at least, it seems unwise to demand speed from the very beginning as this increases the difficulty experienced by the learner in acquiring "correct movements," where such movements are desirable.

In a more recent investigation Windmöller [57] has studied the relative effects of emphasizing accuracy and speed in different types of work. A group of 45 fourteen-year-old boys and girls were set to work on various tasks such as type-setting, cancellation, addition, copying figures, cutting out patterns, arranging cards, arranging figures, bending wire, etc. The subjects performed these tasks three times, being instructed: (1) to work as fast and as accurately as possible, (2) to concentrate on accuracy, (3) to concentrate on speed. The results showed that in very simple tasks emphasis on accuracy reduces speed and does not increase efficiency, since the work is just as good when done fast, but that in work which is difficult, or which requires much attention to small details, the best results are obtained from stressing accuracy alone.

Analytic studies of changes in movement with practice lend support to the viewpoint that increasing speed is associated with the perfection of precision in movement. A complex movement represents a continual and constant process of adjustment or correction of movements.[58] This process has a physiological foundation in the sense that movements are not continuous but proceed by steps which become more numerous when delicate and complex movements are involved. The changes produced by practice tend to the development of a typical "form of movement"—a "whole" or "gestalt"—which is inseparable in so far as its elements are concerned.[59] The changes in the character of movement with practice have been studied by Gemelli [60] through an analysis of the form of the photographic records of successive movements in the task of tracing designs. These records have shown the discontinuity of movement observed by other investigators. They also made it possible to determine (a) the *speed,* (b) the *amplitude,* and (c) the *extension* of *each movement* of flexion and extension, and (a) the *speed,* (b) the *amplitude,* and (c) the *extension* of *each part* of a flexion or extension movement. By means of accurate measurements, Gemelli was able to calculate:

1. A *speed quotient* for each movement of flexion (Q.V.F.)
2. A *speed quotient* for each movement of extension (Q.V.E.)
3. A ratio between these two quotients $\frac{(Q.V.F.)}{(Q.V.E.)}$
4. A *quotient of amplitude* of movement (Q.A.)

When the first half of the movement of flexion is faster than that of

[57] O. Windmöller, "Die Beziehungen Zwischen Arbeitschnelligkeit und Arbeitsgüte," *Psychot. Z.*, 5 (1930), pp. 1–13.

[58] A. Gemelli, "Recherches sur la Nature de l'Habilité manuelle," *J. de Psych.*, 25 (1929), p. 177.

[59] A. Van der Weldt, "L'Apprentissage du mouvement et l'automatisme," *Études de Psychologie*, 3 (1928), pp. 239 ff.

[60] A. Gemelli, *op. cit.*, pp 190 ff

the second half the speed quotient for flexion (Q.V.F.) is greater than unity. If the second half of the movement is faster than the first, the speed quotient is less than unity. This relationship also holds for the speed quotient of extension (Q.V.E.). In so far as the speed ratio of extension and flexion is concerned, $\frac{(\text{Q.V.E.})}{(\text{Q.V.F.})}$ it is greater than unity if the speed of flexion exceeds the speed of extension and vice versa.

In Table 55 are shown the Ratio of Speed of Flexion and Extension, $\frac{(\text{Q.V.E.})}{(\text{Q.V.F.})}$ the number of errors, and the Amplitude Quotient, (Q. A.) for 5 subjects with 15 days of practice in tracing the same designs. The figures show that at the beginning of practice the first part of a flexor movement has more speed than the second. This is also true of the extensor movement. Gradually this relationship is changed and by the end of the 15th day is completely reversed, the second part of the flexor and extensor movements becoming faster than the first. The number of errors decreases with successive periods of practice and, in addition, there is a marked decrease in the amplitude of movement.

These facts suggest that in the course of learning there is a gradual adjustment or adaptation of different muscular movements directed toward a definite end. The chief feature of this adjustment is that the movement gradually acquires a characteristic form or pattern, the chief effect of which is to produce an increasing refinement and precision of movement. This is accomplished by an increase in the number of discontinuous elements in the movement. There is an increasing number of minute arrests which help to accomplish this purpose. At the same time these movements, considered in their ensemble, become more uniform and develop into a "whole" movement or "motor form" having a characteristic internal structure. The movements which constitute a manual ability become definitely fixed into a structural form. In other words, skill results from a process of adaptation of each movement to constitute a "motor form"—*combining elements of accuracy and speed*—intimately bound with perceptual conditions.

In spite of findings such as these, there is no universal agreement that an emphasis upon quality of workmanship alone will also bring about the greatest speed in work. The insistence upon perfect performance of the elements of a job, it is claimed, may be carried to the point where the worker develops habits of deliberateness which are very difficult to overcome.[61] This follows partly from the fact that fast and slow movements do not follow the same pathway. This was early demonstrated by Gilbreth,[62] who found that bricklayers used 3 different sets of movements, (a) when laying bricks quickly; (b) when laying them slowly; and (c) when demonstrating. Gilbreth's position, adopted

[61] H. C. Link, *op. cit.*, p. 133.
[62] F. B. Gilbreth, *Applied Motion Study*, pp. 105 f.

as a result of a study of bricklaying, is shown in the statement that "the most pernicious practice is the generally accepted one of first having an apprentice do perfect work and then attempting to make speed later." [63]

Such differences in the pathway of fast and slow movements may be associated with the relationships between acceleration and deceleration in movement. The speed at which a limb or body moves is never regular.[64] Acceleration occurs after the initial impulse has set the limb moving. Deceleration sets in before the limb finally comes to rest. The relative change of speed is not the same in fast as in slow movement. As a result of this the path covered in movement is apt to be different. In other words, if we learn slowly and then speed up there occurs not

TABLE 55

Changes in the Form of Movement

SUBJECTS	1ST DAY			8TH DAY			15TH DAY		
	Q.V.F. / Q.V.E.	ERRORS	Q.A.	Q.V.F. / Q.V.E.	ERRORS	Q.A.	Q.V.F. / Q.V.E.	ERRORS	Q.A.
1	0.79	35	1.68	0.96	29	1.50	1.01	15	1.05
2	0.81	38	1.72	1.07	24	1.43	0.97	17	1.12
3	0.64	27	1.96	0.91	12	1.22	1.06	9	1.07
4	0.70	41	1.78	1.01	21	1.64	1.05	7	1.12
5	0.85	56	1.70	0.94	34	1.41	1.01	16	1.16

(After Gemelli)

only a change in the rate of movement but an actual change in the pathway of movement. This involves virtually the acquisition of a new habit which may interfere with the final accuracy as well as with the final speed of work. However, in general, there is reason to believe that such a change in the path of movement as may be necessary to speed up work is often easily acquired, perhaps more easily than a habit of perfection when this has not been stressed in the early part of the practice period.

An analysis of laboratory findings suggests that, as a general rule, it would appear to be good practice, in training, to emphasize first the correct performance of the task, but to supplement this as early as possible with an emphasis on speed. The new worker must be trained in such a way that he will never be tempted to develop what the consensus of expert opinion agrees to be bad habits or undesirable methods of work.[65] However, "if the training period is to accomplish its aims the habits of *quick* workmanship must step on the heels of *correct*

[63] F. B. Gilbreth, *Motion Study*, New York, 1911, p. 37.
[64] F. C. Bartlett, *op. cit.*, p. 68.
[65] T. H. Pear, *op. cit.*, p. 74.

habits of workmanship." [66] Very early in the training period an emphasis on quantity of production must be introduced in order to profit fully from a joint stabilization of the *correct* and *fast* pathway into a fixed "motor form" embodying the advantages of speed and accuracy—of high quantity and quality of production.

THE BEST METHODS OF WORK

As indicated earlier in this chapter, the most important single factor in the acquisition of skill is *practice* or *repetition*.[67] Increased motivation may release certain inhibitions in learning and make repetition more effective. The use of the whole or a modified whole-method of training and of other techniques discussed in the preceding pages may facilitate the acquisition of skill, but without repetition it cannot be acquired. However, in order to take full advantage of the influence of repetition in establishing skills it is important to employ during practice only the most effective movements. It is just as easy to establish an incorrect or inefficient response as to set up one which will most effectively meet the needs of the situation. The repetition of a faulty swing in golf, for example, will serve to establish that swing more and more thoroughly [68] and, because of the effect of negative transfer, may later interfere with the development of a swing capable of producing better results. In the same way the repetition of a faulty method of work may result in its settlement and in interference with the learning of better methods. If left to his own devices the new worker may as readily adopt a relatively inefficient method of work as "hit upon" a method calling for the least expenditure of effort on his part. If given an opportunity and the incentive to think through the problem involved in learning, the worker may ultimately choose a better method, but the only certain way of insuring the choice of an efficient method is through instruction from the very beginning in the method or methods which an analysis has shown to be most effective for accomplishing the purpose of the task. Effectiveness, in this connection, must be measured not only by a production criterion, but by the cost to the worker of the methods employed in work. It must be recognized that among the "principal results to be accomplished by training are a greater immunity of the organism to the toxic products of fatigue and an acquisition of the ability to conserve one's energies and direct his impulses to the execution of only such movements as will be of assistance in accomplishing the specific ends." [69]

Instruction in standard or correct methods of work was emphasized

[66] H. C. Link, *op. cit.*, p. 134.
[67] P. M. Symonds and D. H. Case, "Practice vs. Motivation," *J. Ed. Psych.*, 20 (1929), pp. 19–35.
[68] E. S. Robinson, *op. cit.*, pp. 101–02.
[69] J. E. Ash, "Fatigue and Its Effects Upon Control," *Arch. of Psych.*, 31 (1914), pp. 15–16. See also Chapters XXI and XXII.

by Taylor as one of the most important features of scientific management.[70] F. B. and L. M. Gilbreth [71] have frequently drawn attention to the importance of eliminating unnecessary movements and of combining the remaining efficient movements into a standard method of work—the *one best way*—in maintaining industrial efficiency. The best combination of efficient movements, or the *one best way* of work, according to the Gilbreths is determined from a comparison of the constituent elements or therbligs of a task as performed by different expert operatives.[72] Where the timings for the therbligs differ, that which is the shortest is selected, its characteristics determined, and the movement combined with others selected in the same way into a single series of movements constituting the standard method of doing the task. The sum of the times of these constituent elements, plus a percentage for unavoidable delays, plus a percentage to allow for average workers, determine the standard time for the task. This virtually means, as Myers has indicated, that the efficiency engineer applying these techniques "proceeds by analyzing a given operation into a number of different parts, observing and tabulating the movements of another operative who performs another part in the quickest time, and so on; finally collecting into one series the quickest and best movements which is stereotyped and forced on every worker as the 'One Best Way.' " [73]

The manner in which the Gilbreth techniques have been applied by efficiency engineers in determining the movements to be used in work and in training workers has been severely criticized by a number of industrial psychologists. In the first place, the custom of coupling changes in wage systems with changes in methods of work, following motion study, has made it practically impossible to determine the relative contribution of motion study and of the financial incentive in increasing production following the adoption of a new method of training and of work.[74] The question has also been raised as to whether movements observed in different workers, and selected as best largely on the basis of time, can be combined into an independent group yielding the most satisfactory results for all or even most workers. The fundamental error in the technique, as Myers has pointed out, is the neglect of the discovery of both psychology and physiology "that an organism is more than a sum of parts thrown together haphazardly"; that "the individual has characteristics which are not to be found in his isolated parts and his best mode of movement is not necessarily to be derived from a combination of more elementary elements selected from different operatives on a basis of speed." [75]

Beyond the techniques employed in setting up the standard method of work, is the criticism of Gilbreth's fundamental concept of the *one-best-way* of work. Such criticism is based on the grounds that "it is doubtful if a set of movements, however good they may be, can necessarily be regarded as the best movements for every person concerned." [76] According to this viewpoint personal differences in physical and mental make-up must be recognized, and the possibility allowed that the worker may discover a method of work better suited to his requirements than a prescribed one. Moreover, the criticism of the one-best-way denies that speed of work is the best criterion for judging the effectiveness of a movement. The logical development of this viewpoint is the contention that increased output cannot serve as the only gauge of the value of a method of work. There must be combined with speed of work and output a yardstick showing the ease with which the worker can perform the series of movements—i. e., the cost in fatigue and malaise of a prescribed method of work. Reduced fatigue and increased feeling of comfort and satisfaction of work constitute necessary standards in determining the movements to be taught to the worker and in training him for the efficient performance of his task. From this viewpoint the objective of motion study is as well attained by an increased feeling of ease in work, without increased production, as by an actual increase in output.

Although the standard method of work is criticized, it is still recognized that there are certain general principles which can be applied, in the selection of sequence of movement, which will serve (a) to increase the effectiveness of movement in work and (b) to decrease susceptibility to fatigue through economy of effort. Such principles have been formulated by Myers,[77] on the basis of an analysis of psychological and physiological factors in movement, as follows:

1. Successive movements should be so related that one movement passes easily into that which follows, each ending in a position favorable for the beginning of the next movement.

2. The order of movements should be so arranged that little direct attention is needed for passage from one to another. In other words, they are so arranged that the mind can attend to the final aim or end of the operation instead of being distracted by the work of initiating successively the several movements which are involved in a task.[78]

3. The sequence of movements is to be so framed that an easy

rhythm can be established in the automatic performance of the various elements of the operation.

4. From the principles which have been stated follows the corollary that a continuous movement is preferable to angular movements involving sudden changes in the direction of movement.

5. The number of movements should be reduced as far as possible within the scope of limitations suggested above. In general, reducing the number of movements will facilitate a rhythmic method of working and automatization as a means of reducing the volitional direction of work.

6. Simultaneous use of both hands should be encouraged.

7. When a forceable stroke is required, the direction of movement and placement of material should be so arranged that, as far as practicable, the stroke is delivered when it has reached its greatest momentum.

The criticism of the Taylor systems and the Gilbreth concept of the one-best-way of work has not deterred the industrial psychologist from employing the methods devised by efficiency engineers for motion study. Although, in general, there is some objection to the generalized use of the highly refined techniques,[79] there are cases in which these too have been employed. However, in the practical application of motion study techniques the emphasis is upon the ease of work, upon *human* and not primarily upon *economic* efficiency.[80] The difference in point of view is well illustrated in a series of conclusions reached by Farmer with respect to the principles to be employed in the application of time and motion study in the industrial plant.

"1. All time and motion study must be undertaken solely in the interests of lessened fatigue and never in the interests of increased production. When a proper system is carried out, increased production will probably result, and in all cases which have come under the writer's notice has actually taken place; but if increased production is made the object of the experiment the true issue becomes confused, and what purports to be a scientific investigation degenerates into a process of speeding up.

"2. The underlying principle of motion study is rhythm and not speed. We must look upon the best set of movements as the easiest set and not the quickest set.

"3. The proper use of time study is for the analysis of an operation in order to suggest lines of improvement, or to determine the relation between processes, rather than for standardization. The setting of a standard tends to introduce an interfering element in the worker's mind. All the effort of the investigation should be concentrated on lessening fatigue and increasing the ease with which the operation can

[79] E. Farmer, *op. cit.*, p. 32.

[80] See Chapter XXII, pages 464–65.

be performed; other things being equal the operatives will set their own standard which will be satisfactory to all concerned.

"4. Time and motion study is only part of a whole region of study affecting the human element in industry, and can only be carried out in conjunction with the study of other equally fundamental problems." [81]

These principles have been applied by Farmer [82] in a series of factory investigations. Under these conditions, for example, in dipping candy, a group of workers trained in a new method of work, involving a substitution of continuous circular for discontinuous angular movements averaged 88 per cent more in production, with no increase in fatigue, over more experienced girls using the old method. In a coal mine the worker trained to wield the pick in a continuous curved path, instead of backwards and forwards in a straight line, and in the optimal rate for rhythmically swinging the pick with respect to the nature of material, showed a 16 per cent increase in output. In addition, the workers declared they were less fatigued and expressed less dissatisfaction with work than was the case prior to this change in methods of work.[83]

Results such as these indicate the extreme value of motion study and training in correct movements based on a consideration of psychological and physiological, as well as of economic factors. They suggest, in general, as Myers has aptly concluded, that "the training of a new worker shows him one of the most economical methods and prevents in him the formation of bad habits. It need not turn him into a machine any more than if he were left to his own devices. . . . While the employee should be trained from the start in what has been proved to be one of the best methods, he should be at full liberty to substitute another, if he prefers it and can show that it is as effective. To aim at pressing all workers into the same mould is not only to destroy individuality and to encourage needless monotony, but also to run counter to known psychological principles. It is the outcome of so-called 'scientific' management, mechanically formulated by the engineer, in which the mental factors of personality, sentiment, and sympathy are sacrificed to purely physical considerations." [84]

XXI. INDUSTRIAL FATIGUE

Work-work-work
Till the brain begins to swim;
Work-work-work
Till the eyes are heavy and dim!
. . . .

Till the heart is sick and the brain benumb'd
As well as the weary hand.
(THOMAS HOOD, The Song of the Shirt)

In nearly all occupations an increasing strain and intensity of labor are stimulated by modern methods of production.[1] A survey of changes in methods of work has led to the opinion [2] that although machinery, in a sense, has lightened the burden of human toil, it has not reduced fatigue in the worker. In the competition of sensitive nerve and muscle with insensitive steel, the former succumbs to the ever growing demands of a mechanism that knows neither time nor tiredness. It is apparent, according to Mosso, that "machines are not made to lessen human fatigue, as poets were wont to dream. The velocity of the flying wheels, the whirling of the hammers, and the furious speed at which everything moves, these things tell us that time is an important factor in the progress of industry, and that here in the factory the activity of the workers must conquer the forces of nature. Beside these roaring machines are seen half-naked men, covered with sweat, hurriedly pursuing enormous weights, which whirl round as if a mysterious hand were raising them. The hiss of the steam, the rattling of the pulleys, the shaking of the joints, the snorting of these gigantic automata, all warn us that they are inexorable in their motion, that man is condemned to follow them without a moment's rest, because every minute wasted consumes time which is worth money, seeing that it renders useless the fuel and the movement of these collossi." [3]

The introduction of machinery and the specialization of labor have

[1] See *Final Report of the United States Industrial Commission on the Relations and Conditions of Capital and Labor Employed in Manufactures and Several Businesses*, Vol. 19, Washington, 1902, p. 763.

[2] T. Oliver, *Dangerous Trades*, London, 1902, p. 115.

[3] A. Mosso, *Fatigue*, New York, 1904, p. 172.

made it possible to increase greatly the speed of the individual worker. Mechanical aids to increased speed are supplemented by piece rate and other financial incentives which further urge on the worker to a fiercer pace.[4] The increased tension under such conditions of work appears to off-set the savings in muscular force made possible by the machine. The tension, the speed, the subjection to specialization of work and a rhythm uncontrolled by the individual promote *fatigue*, characterized by a "decrease in the power to work, a decrease in pleasure taken in work and a decrease in the enjoyment of the hours spent away from work." [5]

There is tremendous economic waste in the annual cost to industry of excessive and unnecessary fatigue. Gilbreth,[6] for example, ascribes to fatigue brought about by such unsatisfactory working conditions as glare, unsuitable and badly placed chairs, etc., a daily loss of 20 cents per worker in decreased production. The annual loss in the United States attributable to industrial fatigue has been estimated at approximately \$2,500,000,000.[7] Although these figures are merely estimates, they are accepted as reasonable by those concerned with this major industrial problem.[8]

With the objective effects of industrial fatigue, in the form of decreased production, increased spoilage of work, etc., are combined certain less tangible but equally real adverse influences on individual and social welfare. The whole tone of an individual's emotional nature may change under the effects of continued fatigue.[9] Things which were of importance tend to become trivial, and things which were trivial take on undue importance. The "cross" behavior so commonly observed in the fatigued child is duplicated in the unreasonable attitudes and the changed behavior patterns of the adult under the influence of fatigue. "When a man is tired out, he not only broods darkly, but he doesn't think clearly. He does things he wouldn't do when rested. He is easily depressed. He readily imagines injustice. He cannot turn his mind from imagined wrongs against himself to focus it upon the wrong in what he is doing. Worst of all, a tired man is as quick to anger as he is slow and stupid in thought. In violent anger censorship is almost completely suspended. An angry man does without hesitation things which he would never do 'when he is in his right mind.' " [10]

The worker physically exhausted after a long spell at a highly tiring task is incapable of performing adequately the functions of the head of the household. This applies not only to the manual worker; it is

[4] *Hours of Laborers on Public Works in the United States*, U. S. Congress, House Report No. 1703, Washington, 1901–02, p. 9.

[5] F. B. and L. M. Gilbreth, *Fatigue Study*, New York, 1916, p. 5.

[6] F. B. and L. M. Gilbreth, "Unnecessary Fatigue a Multi-Billion Enemy to America," *J. Ind. Hyg.*, 2 (1920), pp. 542–45.

[7] B. J. Newman, "Shop Standards and Fatigue," *Nat'l Safety News*, Nov. 29, 1920.

[8] G. S. Watkins, *Labor Problems*, New York, 1929, p. 34.

[9] G. D. Higginson, *Fields of Psychology*, New York, 1931, p. 405.

[10] E. D. Smith, *Psychology for Executives*, New York, 1928, pp. 101–102.

equally applicable to the "tired business man," who fatigued by the demands of an overcharged daily program, becomes the proverbially unpleasant tyrant of the family circle. Beard has pointed out that "in America 'no lecturer can attract very large crowds unless he be a humorist and makes his hearers laugh as well as cry; and the lectures of the humorists—now a class by themselves—are more required than those of philosophers or men of science or of fame in literature. Americans, who are themselves capable of originating thought in science or letters, scholarly, sober, and mature, prefer nonsense to science for an evening's employment.'" This, according to Beard, "is an inevitable reaction from the excessive strain of mental and physical life. People who toil and worry less have less need for abandonment—for nonsense, exaggeration, and fun." He is convinced that "in no other country is nervous exhaustion so common as in the United States; that in no other country are there so many varieties and so many symptoms of nervous debility." [11]

According to early investigators industrial fatigue affects not only the adjustment of the individual, but influences very directly the welfare of society at large. It is interesting to note that attention was directed toward the debilitating effects of industrial fatigue by the higher proportion of those physically unfit for military service found in industrial as compared with agricultural populations.[12] Increased infant mortality,[13] lowered birth rate,[14] degeneration of the race [15] itself have been ascribed by early investigators to the effects of industrial fatigue. It is probable that the social effects of industrial fatigue have been somewhat exaggerated by early investigators.[16] It is quite likely that factors other than fatigue, such as living conditions in industrial centers, are in large part responsible for many of the evils attributed to it by crusaders against the long work day. At the same time, industrial fatigue remains one of the most important problems in the scientific organization of work. Its elimination or prevention, its utilization as a source of knowledge of the factors involved in adaptation to work, are among the fundamental questions for psychological inquiry in the industrial plant. A brief analysis of the nature of fatigue must necessarily precede the discussion of the findings and practical results of such inquiries.

[11] A. Mosso, *op. cit.*, pp. 198–199.

[12] *Ibid.*, pp. 161 ff.

A. Imbert, "Influence du travail professionnel sur l'organisme," *Nouveau traité de pathologie generale de Bouchard et Roger*, Paris, Tome I, 1912, pp. 751–764.

O. Damner, "Handbuch der Arbeiterwolhlfahrt," *Stuttgart*, 1902, p. 494.

[13] "Prevention of Infant Mortality," *Conference on Prevention of Infant Mortality*, New Haven, Conn., (1909), p. 37.

[14] "Die Fruchtbarkeit der selbstarbeitenden und den arbeitenden Standen angehörigen Frauen," *Z. Soc. Wiss.*, 8 (1905), p. 663.

[15] Mrs. S. Webb, *The Case for the Factory Acts*, London, (1901), p. 46.

[16] J. Goldmark, *Fatigue and Efficiency*, New York, (1912), p. 284.

THE NATURE OF FATIGUE

The word fatigue, as used both popularly and scientifically, refers to three related phenomena: [17]

1. An overt manifestation in the form of reduced output on the task, known as ***work decrement***, 2. a ***physiological state***, involving

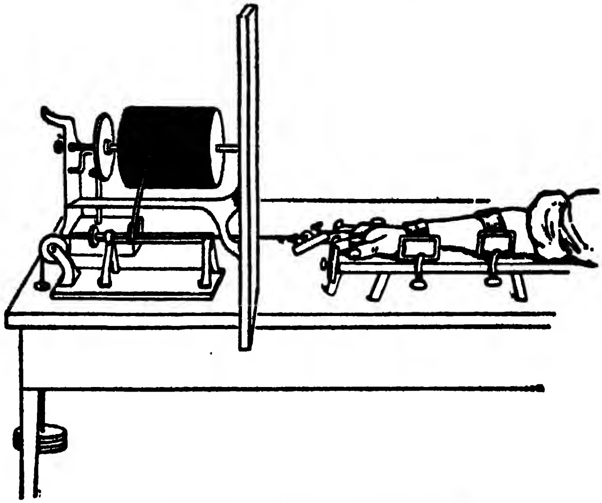


FIGURE 58. *Mosso-Ergograph*
(*After Lehmann*)

changes in organic functions and the production of chemical products of fatigue, 3. a *feeling of fatigue* or tiredness.

An analysis of each of these phenomena must precede a discussion of the incidence of fatigue and of measures taken to reduce its influence in the industrial situation.

DECREASED PRODUCTION THROUGH FATIGUE

Fatigue may be described as decreased capacity for work which results from work. It is the "sum of the results of activities which show themselves in diminished capacity for doing work." [18] The course of reduced productivity, as a result of work, can be illustrated, in its simplest form, through the use of the *finger ergograph* (Figure 58). This instrument permits the exercise of a single finger in lifting a weight attached to the end of a string. Figure 59 shows a typical finger ***ergogram*** obtained in the course of such work. Every stroke rep-

[17] P. S. Florence, *Economics of Fatigue and Unrest,* New York, (1924), p. 99.
[18] *Interim Report,* Health of Munition Workers' Committee, London, (1915).

resents a movement of the lifted weight. The height of the stroke represents the height to which the weight is lifted. By measuring the length of each stroke and combining this with the weight of the lifted load, an exact calculation can be made of the amount of work done by the finger.

The significant feature of this record, for our present purposes, is

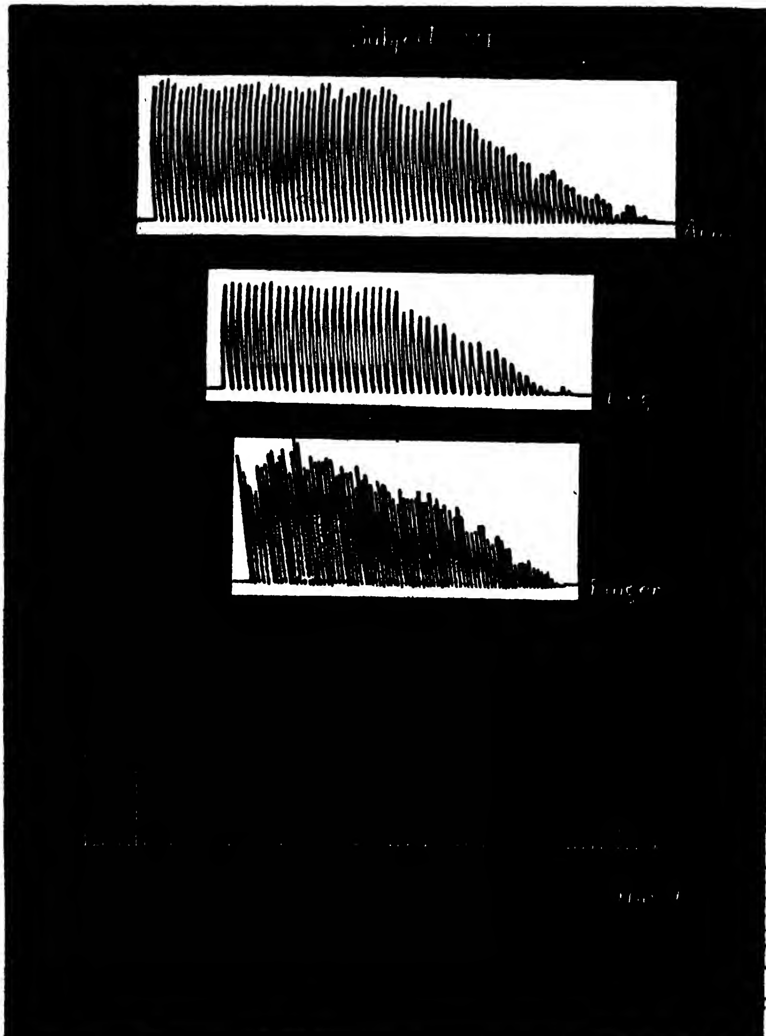


Figure 59. *Typical Ergograms*

(After Yochelson)

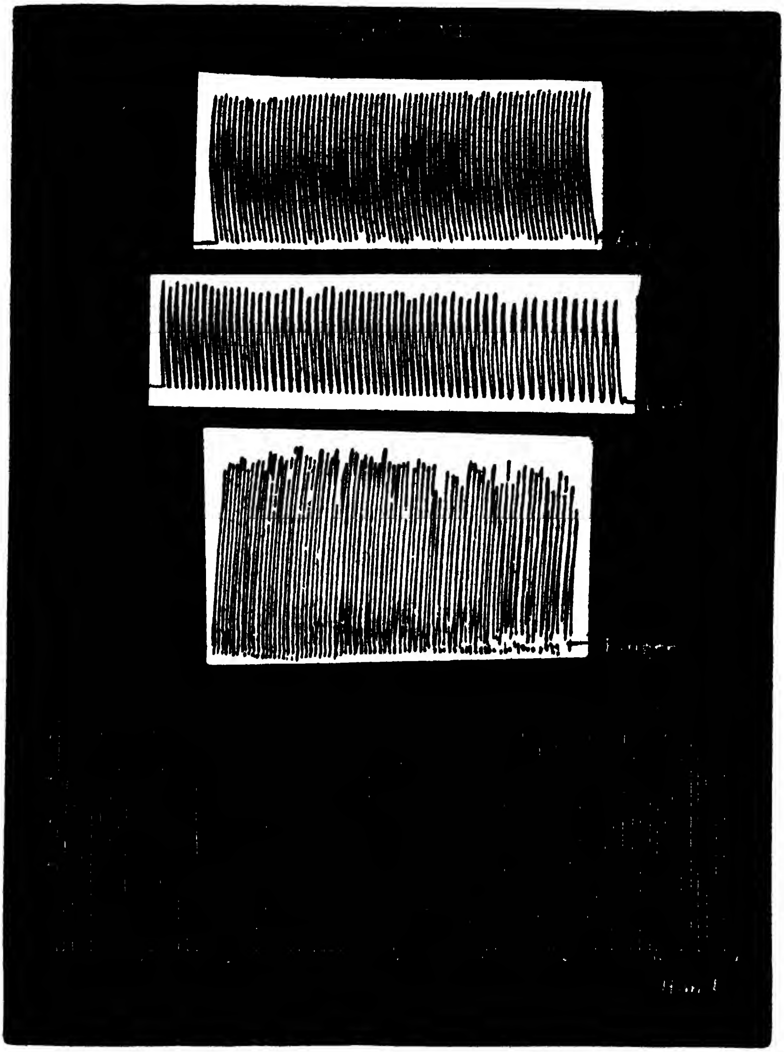


Figure 60. *Typical Ergograms*

(*After Yochelson*)

the fact that it shows a regular decrease in the amount of work from second to second. The strokes decrease in height, showing that less work is being done by the finger, until (in the course of a few minutes) a point is reached, where, *in spite of the desire of the subject,* the weight can no longer be lifted. This represents the point of exhaustion, at which the capacity for work on the part of the finger has

(temporarily) been decreased to zero. In the case of the finger muscle, this lessened capacity for work lasts for only a short period of time. At the end of a rest period of very brief duration, the weight can be again lifted, as a result of the partial *recovery* of the muscle, although the total amount of work done before the point of exhaustion is again reached is generally less than done in the first period of work.

Results obtained with the finger ergograph illustrate clearly the nature of fatigue as decrease in capacity to work as a result of work. There are differences in the shapes of such curves which, according to Mosso [19] and Ioteyko,[20] show characteristic differences between different subjects in their resistance to work. The character of such differences has been studied by Lehmann,[21] who reached the conclusion that from the viewpoint of *energy-constitution* there are three major types; (1) the *energetic,* producing a curve in which at the beginning the strokes maintain a high level then decrease slightly or even increase, and finally gradually drop to a lower level which is maintained for some time before the point of exhaustion is reached, (2) an *an-energetic* type, who produces a curve that drops steeply and maintains a low level before exhaustion, (3) a normally *energetic* or *fatiguable* type of individual whose curve shows a rapid and more or less regular drop associated with a gradual accumulation of fatigue.

Wojchiechowski [22] has used a mercury dynamometer, devised by Henry, in investigating the work curves of 600 subjects, examined at the psychotechnical laboratory maintained in Warsaw by the Polish railways. The mercury dynamometer consists of a rubber bulb filled with mercury. The pressure of the hand on the bulb causes the mercury to rise in a tube. In the model used in this experiment, the height of the mercury is graphically recorded. The height to which the mercury is raised in successive trials gives an index of fatiguability in terms of strength and endurance. On the basis of the findings, the author classified work curves into nine different groups, such as *straight line curve, convex, irregular,* etc., each of which gives a characteristic indication of the energy and endurance of the subject.

Such differences, adequately measured prior to employment, may be extremely valuable in avoiding inefficiency and maladjustment caused by placing the worker at a job for which he is not adapted from the viewpoint of fatigue tendencies. Certain individuals may be adapted to jobs calling for a regular consistent discharge of energy from period to period, as in feeding automatically operated punch presses. Others may be better suited for tasks calling for intermittent spells of rapid, fatiguing work—broken up by periods of lessened activity.

[19] A. Mosso, *op. cit.*, p. 90 ff.

[20] J. Ioteyko, *La Fatigue,* Paris, 1920, pp. 331.

[21] H. Lehmann, "Messung des Kraftimpulses," *Ind. Psychot.*, 5 (1928), pp. 264–272.

[22] J. Wojchiechowski, "Contribution, a l'Étude du Test avec le Dynamographe de Ch. Henry," *Conferència Internacional de Piscòtecnica,* Barcelona, (1930), pp. 350–351.

The view point that there exist characteristic individual tendencies in energy discharge receives support in an unpublished study by Yochelson,[23] who, in the examination of approximately 500 arm ergographic curves (obtained during a period of 4 months, 1929–30), from each of 5 subjects, noted that the curves of each subject conformed to a unique individual pattern. The following year 3 of these 5 subjects were retained for further experimentation and 2 new ones replaced those who could serve no longer. The 3 veterans continued to produce characteristic curves and the new subjects presented 2 forms which were distinctly different from the others. During the second experiment about 900 curves were gathered, including curves obtained by means of leg, finger, and hand ergographs, as well as on the arm ergograph. It is significant to note that *the type of curve remained constant for the individual regardless of the part of the body employed*. These characteristic tendencies are clearly evident in Figures 59 and 60, showing typical arm, leg, finger and hand ergograms for 2 subjects—S-6 and S-7. Introspective evidence shows the existence of a "state of mind" conforming to the shape of the curve.[24]

Evidence of the existence of types, in so far as character of energy output in industrial work is concerned, is found in Poppelreuter's experiment with heavy work under conditions resembling closely those found in the industrial plant.[25] In this investigation the subject is required to punch holes on a narrow roll of paper with a punching device weighing 30 pounds (see Figure 56B). After each hole is punched the weight, raised by both hands, is lowered to its frame while the subject draws out the paper in preparation for the next punch. A graphic record is made of the time taken for each series of ten punches. In parts of the experiment work was carried on for an eight hour work day, the subject being paid at the usual rates for unskilled work. A correlation of 0.88 between the production during the first hour of work and production during two consecutive full days is cited in evidence of established individual tendencies toward quantity of production which reflect, in part, the fatiguability of the individual. Of particular significance, in this connection, is the observation that the most significant characteristic of the individual adapted for heavy work is not the quantity of his production, but the fact that his work curve shows a consistent regularity of good output.

[23] From data kindly supplied by S. C. Yochelson, Yale University.

[24] The findings on fatigue types are critically reviewed in two recent articles by Skawran, who also reports valuable findings on the relationship between type of ergographic curve and body type as classified by Kretschmer. See P. Skawran, "Die Typologie der Ergogramme und ihre Beziehung zu Energie-Typen und zu den Körperbautypen Kretschmers," *Psychot. Z.*, (1931), 10–19, 49–63.

[25] W. Poppelreuter, "Tatigkeit und Ergebnisse der Forschungstelle für industrielle Schwerarbeit bei den Gelsenkirchener Bergkerks-aktien-Gesellschaft, Abt. Schalk," *Psychot., Z.*, 1 (1926), pp. 126–131.

EFFECT OF FATIGUE UPON INDUSTRIAL PRODUCTION

Fatigue impairs man's working power in the industrial plant in the same way as it interferes with the activity of a single muscle in the laboratory situation. The situation is not, of course, altogether analogous.[26] As Myers [27] has pointed out, the industrial worker, unlike the ergographic experimenter, does not continually put forth his utmost power. He differs further in the fact that he is not always using the same joint or the same muscle. The worker, unlike the subject on the finger ergograph, may vary his posture, change the poise of his muscle and even the muscles used for the same work, so that the previously used poise or set regains its freshness. Moreover, it is seldom, or ever, that he is required to contract his muscles against so heavy a weight that a relatively small number of lifts produces a complete, if only momentary, loss of the ability to continue the task. In addition, the worker regulates his output according to the length of the period during which he knows that he has to work. He knows better than to exhaust himself in a short period by using his maximum effort, as does the worker in an ergographic experiment. The conditions of laboratory experiment on fatigue differ in other ways from those of work-a-day life. "Muscular fatigue in the factory cannot be isolated, as in the laboratory, from such influences as skill and intelligence which depend on the proper functioning of the higher levels of the central nervous system." [28] However, studies in the industrial plant show a typical drop in production toward the end of a working spell which, after careful allowance is made for all other factors, can only be ascribed to fatigue. The rate of production generally increases during the first few hours of the working day. Output begins to fall off after the third or fourth hour and declines more or less steadily so long as work is continued.[29] There is a short period of increased production after the lunch hour, but this soon falls off again. Workers scarcely ever turn out as much work in the course of the post-luncheon period of work either in the day shift or on the night shift, as during the pre-luncheon spell of work. These changes in output are graphically shown in a typical production curve reproduced in Figure 61.

For many years it was believed that the shape of this work curve is determined by *diurnal* or *daily rhythm* of work. However, tests made by Hollingworth [30] upon 10 subjects for a period of 10 days, in connection with many different types of work, showed that the same sort of curve of efficiency is obtained when the work begins at 10:30 A. M., as at 7:30 A. M., the curve as a whole being shifted some-

what ahead. Efficiency at any period of the day appears to depend not on an organic rhythm, but rather upon the number of hours spent at work immediately preceding the period of observation.

The regular features of the daily work curve, as of other work curves, are due to the operation of general factors determining efficiency in all forms of work. Chief among these are *practice* and *fa-*

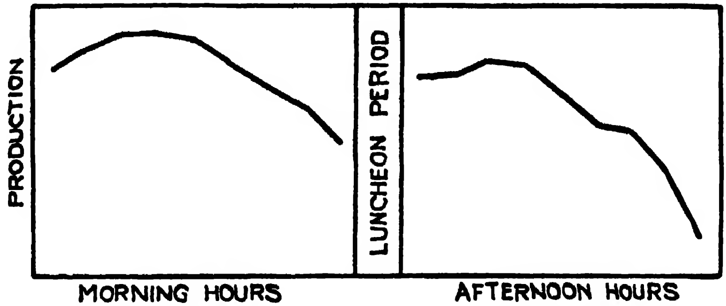


FIGURE 61. *Typical Daily Production Curve*

(*After Burtt*)

tigue, which are mutually antagonistic forces. Practice has a tendency to increase production; fatigue tends to decrease it. The effect of practice in counter-balancing the influence of fatigue will vary in accordance with the expertness of the worker on the task.[31] The effect of fatigue will show itself earlier where there is little or no practice-gain. A significant practice-gain may for some time mask the effect of on-coming fatigue. In addition, *incitement, settlement,* and *spurt* help to determine the shape of the work curve. The relatively small output during approximately the first hour of work, when the worker has been least exposed to work, results, in part, from the fact that for at least a portion of that period the workman is not properly "warmed up" to his job. The process of "warming up" is technically known as *incitement* and is associated with a period of *settlement,* or neglect of distracting conditions. An analysis of the findings of a recent study by Skaggs [32] suggests that the warming up phenomenon is largely a matter of attitude, mental alertness, and attention expressed in the fact that it takes some time for the subject to become absorbed in his task and to disengage his mind from other matters. Incitement and settlement show themselves at the beginning of work and in co-operation with the practice-effect produce the steep rise which the work curve shows at this stage. This period of increasing production is followed by a period of maximum production which is itself suc-

ceeded by a gradually decreasing rate of output as the effect of fatigue makes itself felt. It is fair to assume that if lunch did not intervene, the decrease would be progressive until the end of the day's work. Lunch and the accompanying rest period serve not only to arrest the decrease in production but lead to a second period of incitement by virtue of which production rises to a somewhat higher level than that at which the worker leaves off before lunch. This continues for a short period, and is almost invariably followed by a marked and regular decrease in output reflecting gradually increasing fatigue. However, under certain conditions, as in repetitive, monotonous work,[33] or as the result of extreme excitement in emotional states, production may be affected by temporary *spurts,* of which the most striking are the *initial spurt,* occurring when the subject starts fresh at his work, and the *end spurt,* as he realizes that the end of the working spell is approaching. Certain of the specific conditions producing such spurts are discussed below, and more particularly on pages 536–47, Chapter XXIV.

The effect of *practice, incitement, settlement,* and *spurt* also appears in the weekly curve. These account, in part, for variations in daily production throughout the week noted by independent investigators. The play of these factors is evident, for example, in Richter's [34] study of output in a machine shop. When the average output for Wednesday is taken as 100 per cent, the average daily production for 6 weeks, of 5 experienced workers engaged in cutting threads in brass parts, and of 4 experienced workers employed for 5 weeks in slitting the heads of brass screws, is as shown in Table 56.

The lower production on Monday results from loss of skill during the week-end rest. *Incitement* and *settlement* extending over Monday and Tuesday lead to a high point in production on Wednesday. From this point production starts to fall,[35] but on Saturday there is an increase, or "spurt," reflecting an anticipation of the end of the week's work which is sufficient to overcome the physiological fatigue, which is undoubtedly present.[36]

The curve illustrated in Figure 61, represents the *general* form of the daily production curve obtained when fatigue, or a diminution in the power to work resulting from work, is the predominating factor in determining rate of production. However, the curve of industrial output varies with the kind of work done.[37] When the work involves

[33] See Chapter XXIII, pp. 521–27.

[34] W. Richter, "Leistungssteigerungen in der Blankschraubenfabrikation durch Einführung von Zwangspausen," *Ind. Psychot.*, 8 (1931), p. 135.

[35] The lower production on Thursday, as compared with Friday, is explained by Richter as resulting possibly from the fact that workers were paid on Wednesday, and tended to obtain less rest on that than on other work days.

[36] As suggested elsewhere, the occurrence of such an end spurt may be related to the presence of monotony, anticipated relief from which may account for a rise in the production curve when, if fatigue alone were involved, it could reasonably be expected to drop. See pages 521–27, Chapter XXIII.

[37] K. A. Tramm, *Psychotechnik und Taylor System,* Berlin, 1921, pp. 122–129.

merely strenuous muscular exertion, there may be noted a rapid and early rise in the work curve to a maximum followed by a fairly definite fall during the morning spell. After lunch there is a fair recovery, succeeded by a progressive, well-marked fall throughout the afternoon. When the work is characterized by skill and dexterity, there is a slower, more gradual rise to the maximum, followed by a less obvious fall during the morning, a less complete recovery after luncheon, and a much smaller drop at the close of the afternoon. In machine work, where the output is largely independent of the human factor, the curve of output may be expected to reach a maximum at about the third hour of the morning spell, then to fall slightly, and during the afternoon to maintain so high a level that the output may exceed, or at least equal, the morning's output. When the factor of rhythmic action is added to skilled and strenuous movement, the afternoon's output tends to remain high, and no fall may occur in the last hour of the day. In addition, the morning output will start at a low level and increase enormously during the first three hours of work, falling towards the end of the morning less than in purely muscular work, but more than in merely dexterous work.[38]

TABLE 56

Daily Variation in Production

SLITTING BRASS SCREWS		CUTTING THREADS
96.3	*Monday*	94.7 per cent
97.9	*Tuesday*	96.5 per cent
100.6	*Wednesday*	100.06 per cent
98.6	*Thursday*	97.9 per cent
99.6	*Friday*	98.6 per cent
102.7	*Saturday*	104.5 per cent

(After Richter)

With the overt manifestation of fatigue in the form of decreased quantity of production is generally associated a reduced *quality* of output. The number of errors in type-setting, for example, was found to increase as output, following the typical fatigue curve, decreased.[39] In the auditing department of a large railway company records were made of the number of checks handled and number of mistakes on the part of 18 clerks who wrote approximately 115,000 checks in the period of the study.[40] The findings showed few mistakes during

[38] C. S. Myers, *Mind and Work*, London, (1920), pp. 62–63. (See also C. S. Myers, *Industrial Psychology in Great Britain*, *op. cit.*, pp. 70–71.)
[39] B. Muscio, "Lectures in Industrial Psychology," London, (1920), pp. 69–70.
[40] E. G. Martin, *op. cit.*, p. 349.

the early part of the day. Numerous errors appeared at the fourth hour of work and continued with comparative frequency from that time to the end of the working day. The incidence of error in afternoon hours averaged 14 per cent greater than in the morning hours.

PHYSIOLOGICAL CHANGES IN FATIGUE

Results such as those cited above indicate clearly that diminished output, accompanied generally by lowered quality of work, represents an overt manifestation of fatigue. Industrial fatigue may be described, first and foremost, as "a diminution of working capacity caused by length or intensity of some activity in a 'gainful' occupation." [41] As a practical matter, one chief problem in industrial fatigue is that of reducing the extent of diminution in output resulting from work.

Fatigue also presents itself in the form of changes in the physiological balance of the body.[42] Experiments with isolated muscles of lower animals and of man have led to the belief that the most important physiological factors in fatigue are:

1. *The reduction, in the muscle, of the amount of energy producing material* and 2. *The accumulation of waste products in the muscle and blood stream.*

The energy producing material employed in muscular activity is a starch-like substance—*glycogen,* which is readily converted into sugar. This is the fuel which the muscle uses in its activity, in the same way as the locomotive employs coal. Also, in much the same way as the locomotive and the automobile, a supply of fuel is always carried in the muscle.[43] Without it, the muscle is incapable of moving. The *glycogen* consumed in the course of muscular activity is replaced by sugar brought to the muscle by the blood, which obtains its supply from the liver, where sugar is stored, or from the intestines, where it is absorbed from food in the course of digestion.

The activity of the muscle depends also upon the rate of formation and of disposal of toxic substances which are formed in the course of work. The contraction of the muscle is associated with the conversion of sugar into *lactic acid,* a powerful re-agent, formed inside of the muscle fibres, which seriously interferes with the continued activity of the muscle. Lactic acid is re-converted into glycogen, but this can only occur in the presence of oxygen. Oxygen, like sugar, is brought to the muscle by the blood, which absorbs it from the air through the walls of capillary tubes in the lungs. However, if activity is prolonged, as in the case of even very moderately sustained muscu-

[41] P. S. Florence, *op. cit.*
[42] J. Amar, *Le Moteur Humain et les bases scientifique du Travail professionnel,* Paris, 1923, (rev. edition).
[43] A. V. Hill, *Living Machinery,* New York, (1927), p. 62.

lar activity, or where many muscles are employed at one time, oxygen cannot be supplied at a fast enough rate to convert the entire amount of lactic acid formed in the course of work. There is not an immediate interference with activity, because for a period of time the muscle can react without oxidation. The muscle, under such conditions, is said to go into "oxygen debt" of which breathlessness is a sign and from which the individual does not recover until some time after the bout of exercise or work. However, the accumulation of lactic acid within a short time produces local fatigue—evidenced overtly in restricted capacity for movement.

The importance of the oxygen supply in delaying the onset of fatigue, through the conversion of lactic acid, has been illustrated in experiments involving muscular activity in the absence of oxygen and in the presence of various amounts of oxygen.[44] If two legs of an animal are stimulated simultaneously,[45] the circulation of one of them being cut off, fatigue occurs much earlier in the muscles without the blood supply. This is further evidence that the onset of fatigue is affected appreciably by the efficiency of the blood supply. The rate of oxidation of the lactic acid appears to be the chief factor in this situation, although the formation of another waste product, carbon dioxide, in the process of converting lactic acid to glycogen, represents another physiological variable in this situation.

Under many conditions of physical activity, in the case of man as well as in the lower animals, the formation of lactic acid quickly outstrips its re-conversion into sugar.[46] The surplus is washed out by the blood and carried by it to all parts of the body. This further handicaps the recovery of the active muscle by depleting its store of glycogen which, having left the muscle in the form of lactic acid, cannot be re-converted for service at that particular spot. In addition, the diffusion of lactic acid by the blood stream may affect muscles and nerves not actually engaged in work and supplement local muscular by more general fatigue. It is because of this distribution of lactic acid that the individual engaged in a simple task involving the activity of only a few muscles may experience both a marked feeling of *general* bodily fatigue and an actual reduction in the efficiency of muscle groups not used on the job. The effectiveness of blood vitiated by fatigue products in producing fatigue is illustrated in the fact that the blood of a fatigued animal, introduced into the vascular system of another, produces overt manifestations of fatigue in the form of labored breathing, increased pulse rate, etc.[47]

[44] *Ibid.*, p. 60.

[45] R. J. S. McDowall, "The Physiology of Industrial Fatigue," *J. Ind. Hyg.*, 11 (1929), p. 13.

[46] E. G. Martin, *op. cit.*, p. 347.

[47] A. Mosso, *op. cit.*, p. 119.

MUSCULAR, NERVOUS, AND MENTAL FATIGUE

The accumulation of lactic acid and depletion of glycogen in muscle do not completely explain the diminished activity of muscle resulting from its use. There is reason to believe that the supply of glycogen in the muscle is never completely consumed. This observation, combined with the muscular response to a direct electrical stimulation of either its nerve or of the muscle itself,[48] have suggested that the local muscles, by setting up inhibitory stimuli originating in the muscle spindles, bring about the inhibition of voluntary effort.[49] It is also possible, that "in the course of prolonged exertion the contact between nerve cell and muscle cell literally becomes fouled, supposedly by products of activity,"[50] so that the muscle cells are shielded from further stimulation by nervous current. The change in *chronaxia,* or in the strength and duration of the stimulus necessary to produce muscular response, observed by Lapicque,[51] may be due to the presence of such fatigue products at the motor nerve ending. There is also a possibility that the excessive use of junctions, or *synapses,* between nerve cells in the spinal cord and brain may cause actual nervous fatigue[52] resulting in impaired conductivity of the nervous elements. Through the accumulation of fatigue products, resulting from activity of the nerve cells themselves, impulses are blocked at the synapse or shunted to other pathways. Under such conditions the gradual elimination of higher nerve centers would account for the decrease of fatigue as work becomes progressively automatized. This change is apparent, for example, to all who have learned to drive an automobile. It is evident in the greater fatigue of workers while engaged in learning a repetitive job—in establishing the pattern of movement, as compared with that occurring among trained workers. It is also possible that fatigue products brought by the blood stream from muscles have the same effect as activity on the part of the nervous elements. In other words, muscular activity may produce *nervous* as well as *muscular* fatigue.

The direct functional impairment of nerve cells located at the higher levels can account for "mental fatigue," evident in work decrement and in the feeling of weariness experienced in purely "mental" opera-

[48] *Ibid.,* p. 99.
T. Hough, "Ergographic Studies of Neuro-muscular Fatigue," *Am. J. Physiol.,* 5 (1901), pp. 240–266.
[49] C. Reid, "The Mechanism of Voluntary Muscular Fatigue," *Quart. J. Exp. Physiol.,* 19 (1928), p. 17 ff.
C. S. Myers, "The Study of Fatigue," *Pers. J.,* 3 (1925), p. 322.
C. S. Myers, "Conceptions of Fatigue and Adaptation, *Psych. Rev.,* 31 (1925), pp. 1–16.
[50] H. M. Johnson, "The Real Meaning of Fatigue," *Harper's,* 158 (1929), p. 187.
[51] L. Lapicque, "Introduction au test de fatigue musculaire basé sur la chronaxie," *Institut Lannelongue, Notes et Memoires.* Paris, 2 (1921).
[52] C. S. Sherrington, "Correlation of Reflexes and the Principle of the Common Path," *Proc. Brit. Assn. Adv. Sci.,* (1904), pp. 728–741.

tions such as silent reading, mental arithmetic, the solution of verbal intelligence problems, etc. However, "mental fatigue" or "brain fag" may also be the result of the actual contraction of vocal muscles, in the process of thinking, as suggested by Watson,[53] or in other muscular activity in gesturing, in changes of facial expression, changes of body position, etc., associated with mental work.[54] As a practical matter, in so far as fatigue-effect is concerned, there appears to be little difference between so-called muscular and mental fatigue. "Just as too continuous work with hands or arms may lead to a temporary loss of control over these members, so, also, too continuous mental work may lead to a temporary loss of control over the muscles involved in that work. After too much walking, a person may be restless and unable to quiet himself, and after too much thinking, one may be unable to relax the facial muscles." [55] Regardless of the cause of fatigue and of the physical and physiological mechanisms involved, the chief problem is that of so changing conditions of work as to decrease to the minimum its unfavorable effects.

ADDITIONAL PHYSIOLOGICAL CHANGES IN FATIGUE

The physiological accompaniments of fatigue are to be seen not only in increased lactic acid, but in other bodily changes.

Respiration is the function which appears to be most visibly affected by continued work. The labored breathing of the runner who

> "Suffers his comrades to pursue their flight
> Until he hath relieved his panting chest." [56]

is the classic example of this change, which has been measured in connection with varied forms of activity by Hill [57] and others.

Work also produces changes in the blood, the cardiovascular and the alimentary systems, in the endocrine glands and the nervous system.[58] Marked transformation in blood cells and chemistry,[59] varia-

tions in pulse rate and blood pressure,[60] increased concentration of blood sugar in plasma and corpuscles in short strenuous exercise, followed by a drop in blood sugar in longer periods of work,[61] demonstrable changes in urine and body secretions,[62] have been observed in fatigue.

The character of such metabolic modifications in individual func-

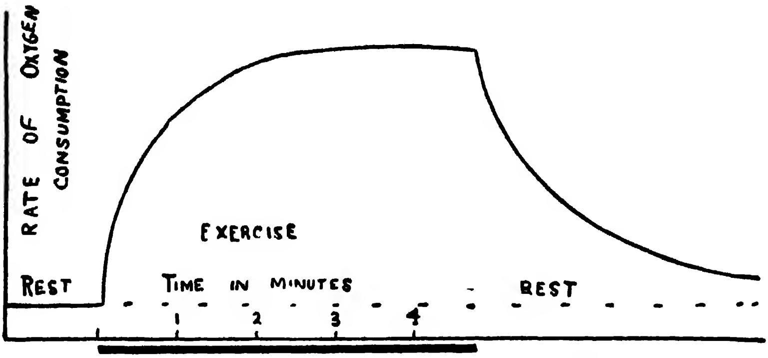


FIGURE 62 A. *Rate of Oxygen Consumption Before, During and After Exercise. The period of exercise is marked by a thick horizontal line.*

(*After Hill*)

tions is to be observed in Figure 62A showing changes in consumption of oxygen before, during, and after exercise, and in Figure 62B, showing the average curves of pulse rate, pulse pressure, and pulse product (pressure x rate) of 22 workers in a plant manufacturing rubber shoes and garters. It can be seen that the average curve for pulse product tends to drop throughout the day, coincident with the appearance of fatigue, as revealed in a decrease in rate and quantity of production,[63] and increased physiological cost of work.

The combination of metabolic changes produced in the course of

[60] R. Dodge, "Mental Work, A Study in Psycho-dynamics," *Psych. Rev.*, 20 (1913), pp. 1–42.

O. S. Lovekin, "The Quantitative Measurement of Human Efficiency Under Factory Conditions," *J. Ind. Hyg.*, 12 (1930), pp. 99–120, 153–67.

[61] F. A. Moss, J. H. Roe, O. B. Hunter, L. French, and T. Hunt, "The Measurement of Fatigue by Physiological Methods," *J. Exp. Psych.*, 14 (1931), pp. 423–438.

[62] V. Scott, "The Present Status of Our Knowledge of Fatigue Products," *U. S. Public Health Rep. Bulletin*, 465, (1918).

P. Schenck and K. Craemer, "Der Einfluss schwerer kòrperlicher Arbeit auf den Menschilichen Stoffwechsel," *Arb. Physiol.*, 2 (1929), pp. 163–188.

A. F. Koriakina and A. N. Krestownikoff, "Über die quantitativen Verhältnisse von Milchsäure im Schweiss und von Eiweiss im Harn bei Muskelarbeit," *Arb. Physiol.*, 2 (1930), pp. 421–426.

A. F. Koriakina, E. B. Kossowskaja and A. N. Krestownikoff, "Über die Schwankungen des Chloridgehaltes im Blut, Harn und Schweiss, bei Muskeltätigkeit," *Arb. Physiol.*, 2 (1930), pp. 461–465.

[63] O. S. Lovekin, *op. cit.*, p. 159.

muscular work has been investigated in a recent study by Moss and others.[64] Ten university students, between the ages of 18 and 35, spent 15 minutes riding a *bicycle ergometer.* This is an ordinary bicycle electrically connected so that the amount of work performed in

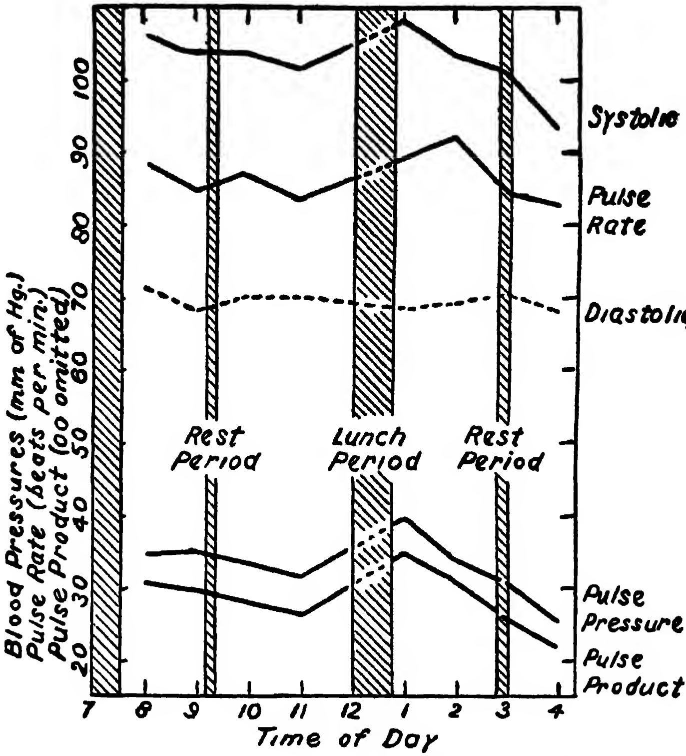


FIGURE 62 B. *Diurnal Variations in Average Curves for Twenty-two Workers in One Factory Department*

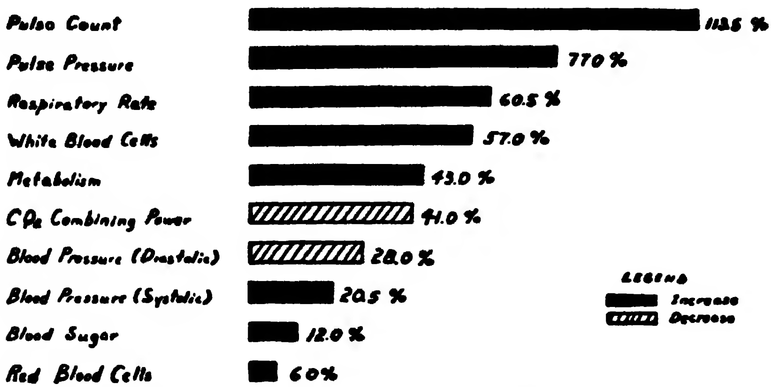
Averages: systolic, 104; pulse rate, 86.9; diastolic, 70; pulse pressure, 34; pulse product, 2, 941; standard deviation, ±382

(*After Lovekin*)

pedaling can be varied. This was kept constant for all subjects of the experiment. In the case of each, studies were made before and after exercise of blood pressure, pulse, carbon dioxide combining power, blood sugar, haemoglobin, blood counts, metabolism, and respiration, urine (chemical and microscopic), and electro-cardiograph records. The direction and amount of physiological change in each of these with fatigue are shown in Figure 63.

[64] F. A. Moss. et al., *op. cit.*

The results bear out the theory that fatigue is in part a phenomenon of changed metabolic relations. They also indicate that these changes are not simple in character, limited, as was believed by early investigators, largely to an increase in lactic acid, but involve a very complex modification of many functions. Of these, in the case of man at work, changes in blood pressure and rate of pulse and in oxygen consump-



Medians of Physiological Changes with Fatigue

FIGURE 63

(*After Moss, Roe, Hunter, French, and Hunt*)

tion would seem to be the most significant from the viewpoint of developing objective and simple methods of measuring energy expenditure in the factory. From the viewpoint of the physiology of fatigue, the efficient worker may, in the long run, be conceived as the one who attains a high production per unit of energy and succeeds in maintaining an organic equilibrium as exertion increases.[65] The application of this principle assumes that increased expenditure of energy, revealed in metabolic changes, is symptomatic of fatigue.

THE FEELING OF FATIGUE

The sensation of weariness which appears with prolonged work represents another expression of fatigue. It is the subjective sign of deep seated physiological changes accompanied by decreased capacity for work. Unfortunately, the feeling of fatigue represents an amorphous combination of diverse factors such as "dislike for a continuation of work," "lassitude," "weariness," a "feeling of effort in directing attention upon the task and its control," "limp sensations,"

[65] O. S. Lovekin, *op. cit.*, p. 167.

"laziness," "changes in emotional attitude," [66] with perhaps a desire for rest or repose as the only common factor. Such subjective states may be associated with the passage of inhibitory nervous impulses from the muscle to the central nervous system. These not only make it more difficult for impulses to descend to that muscle to produce volitional response, but they awaken consciousness in the form of discomfort and of other characteristic subjective symptons of fatigue.[67]

The feeling of fatigue normally plays a defensive rôle in preventing exhaustion.[68] This may account for the fact, observed by Ioteyko,[69] that the feeling of fatigue increases more rapidly than the rate or intensity of work itself. In this respect the relationship is inverse to that for sensations in general, as expressed in *Weber's Law*. In the case of such sensations, the intensity of conscious experience follows an arithmetic progression paralleling a geometric progression of the intensity of stimuli. The relationship between the strength of stimulus and the intensity of consciousness is reversed in the case of the feeling of fatigue.

Although the feeling of fatigue plays a protective rôle in preventing exhaustion and *generally* increases in intensity more rapidly than the rate or amount of work, it does not serve as an index of the physiological state of the body or of its capacity for continued work. A short walk, involving actually little use of muscles, may produce a pronounced feeling of fatigue to an individual who may dance all night without complaint.[70] Another may be on the verge of complete exhaustion, as a result of overwork, without feeling fatigued.[71] Laboratory investigations have shown that a given task may be done as rapidly and as accurately when the subject reports a feeling of fatigue as when consciousness of fatigue is altogether absent.[72] Particularly in mental work, the feeling of fatigue may be experienced when objective measures of production show progressive increase in the amount of work.

This is well illustrated in an experiment reported by Poffenberger [73] in which 12 subjects worked continuously for approximately 5½ hours at inserting words into sentences in order to complete the meaning. The work was divided into 15 equal units with a rest pause between the 14th and 15th units. At the beginning of the experiment, and at the end of each unit of work, each subject indicated the quality of his feeling on a scale of 7 degrees ranging from "Extremely Good" to "Extremely Tired." In Figure 64 are shown the average output curve and

[66] C. S. Yoakum, "An Experimental Study of Fatigue," *Psych. Monograph*, 46 (1909), p. 113.

[67] C. S. Myers, *Study of Fatigue, op. cit.*, p. 322.

[68] V. Dhers, *Les Test de Fatigue*, Paris, (1924), p. 10.

[69] J. Ioteyko. *op. cit.*, p. 160.

[70] T. H. Pear, *Fitness for Work*, London, (1928), p. 84.

[71] *Ibid.*, p. 134.

[72] V. Dhers, *op. cit.*, p. 12.

[73] A. T. Poffenberger, *Applied Psychology*, New York, (1927), pp. 134–135.

the average feeling curve for all subjects. It is clearly evident that in spite of a gradual drop in the feeling curve from good to tired the output curve remains fairly constant throughout the entire period of work. Observations made in the course of the experiment show increasing feelings of weariness, irritability, restlessness, outbreaks of profanity, and threats on the part of the subject to discontinue work. In spite of these subjective feelings and of the expressions of fatigue, the

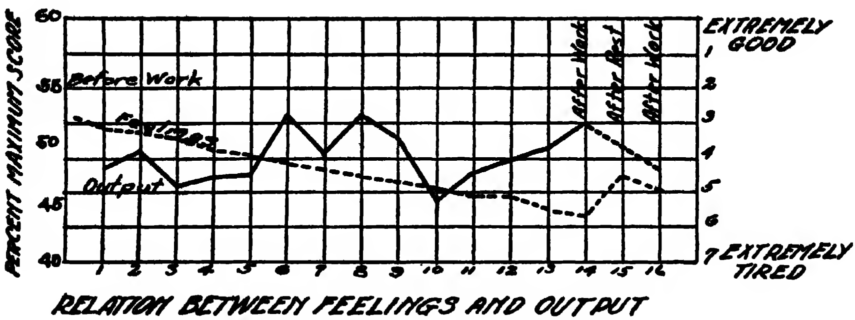


FIGURE 64

(After Poffenberger)

influence of the group, combined with a high rate of pay for the work, served to keep production fairly constant. In other instances, as Rivers has shown, there may be a total absence of the feeling of fatigue although, objectively, there appears a reduction in the quantity and quality of work.[74]

The mercurial qualities of the feeling of fatigue are illustrated in the modified shape of the production curve and in the attitudes of different individuals in monotony producing work. This is to be discussed in Chapter XXIII. They are further evident in the fluctuations of conscious state under excitement, in such pathological conditions as hysteria and hypnosis (when heavy work can be done with little or no feeling of fatigue). In addition to suffering from these disadvantages as an index of the effect of work upon bodily economy, the feeling of fatigue, because of its subjective character, cannot be measured with any degree of accuracy. For these diverse reasons, it is not difficult to agree with investigators in this field in their unwillingness to accept the feeling of fatigue as a valid basis for judging the effect of work upon the efficiency and adjustment of the individual in the industrial and other situations.

[74] W. H. Rivers, *Influence of Alcohol and Other Drugs on Fatigue*, London, (1908), pp. 136. "On Mental Fatigue and Recovery," *J. Ment. Sci.*, 42 (1896), pp. 525–529.

NECESSARY AND UNNECESSARY INDUSTRIAL FATIGUE

The purpose of fatigue study in industry is to reduce the influence of fatigue in decreasing production, in wearing down the organism, and in producing unpleasant feeling tones. The problem of fatigue reduction involves a distinction between *necessary* and *unnecessary* fatigue.[75] All work involves fatigue. In the movement of the smallest muscle in the body glycogen is consumed, lactic acid and other fatigue products are created and the capacity of that muscle to work is necessarily decreased. It is therefore impossible to speak of the total elimination of fatigue in industry. The very act of performing the duties of the job induces fatigue or decreased capacity for work. A small amount of fatigue products, it is true, may actually be of advantage in stimulating activity, in the same way as small concentrations of alcohol and narcotic agents may improve performance.[76] However, this improvement is in itself an indication of bodily impairment, inasmuch as fatigue products are being created and bodily fuels diminished at a rate which progressively unfits the individual for further production. Although a short period of work may be beneficial for bodily economy, longer periods in any task result in an *accumulation* of fatigue products. Unless they are removed by rest, and fuel created by a proper supply of food, fatigue may become *chronic*, leading possibly to a complete exhaustion ordinarily observed in so-called "physical" and "nervous breakdowns."

The fatigue which follows from the very fact that groups of muscles and nerves are used in certain pattern in a given job is known as *necessary* fatigue. Necessary fatigue cannot be totally eliminated, but even the amount of such fatigue can be reduced. If the best methods of work are used and the most suitable worker has been chosen for the job, the amount of necessary fatigue—measured in terms of energy expenditure—induced by the work may be described as *normal* for that work. However, necessary fatigue becomes abnormal, from the viewpoint of the worker engaged in the task, if that worker is not adapted for the task or if changes in health or other conditions intervene to produce modifications in physical economy. The most important factor in the reduction of the necessary fatigue involved in a job is the *selection* of men physically competent to perform the duties of the job. The job of shovelling coal, for example, requires a greater degree of physical force, of energy, than does the job of watchman at a country crossroad on a railroad. To select a man who rates low in energy for the job of shovelling coal is to increase the fatigue which necessarily ensues from the performance of the muscular movements involved in shovelling the coal. Workers A and B may perform the same series of muscular movements, involving the same discharge

[75] F. B. and L. M. Gilbreth, *Fatigue Study*, New York, (1916), pp. 13–14.
[76] H. M. Johnson, *op. cit.*, p. 189.

of energy in terms of kilogram-meters, but because worker B possesses less energy—less capacity for continued muscular movement—than worker A, fatigue sets in much more rapidly and is much more serious in its consequences.

Unnecessary fatigue is decreased capacity for work induced not by the nature of the work, or the nature of the individual doing the work, but by unfavorable working methods or conditions of work. These bring about useless discharge of energy and, therefore, an unnecessary decrease in the capacity for work. Unnecessary fatigue, to be discussed in greater detail in the next chapter, can be totally eliminated. It involves an elimination of those working conditions and methods of work which result in an unnecessary discharge of energy, and the substitution of conditions of work which will do away with such an unnecessary discharge of energy.

THE MEASUREMENT OF INDUSTRIAL FATIGUE

The reduction of industrial fatigue involves its measurement. Necessary fatigue cannot be decreased unless it is possible to measure the fatiguability of the worker. Likewise, the effect of changed methods and conditions of work in reducing unnecessary fatigue can only be determined if there is available an adequate measure or test of fatigue.

Experimental work has been carried on with many types of fatigue tests—*physical, chemical, physiological, psycho-physical, mental,* and *production.*[77] The distinction among these are in some cases arbitrary but, in general, the classification appears to be useful in describing the diverse approaches in the measurement of fatigue.

Among *physical* tests are those measuring the momentary energy output of the individual, such as the hand dynamometer, the mercury dynamometer, the water dynamometer,[78] the Martin spring balance for registering the force exerted by six different sets of large body muscles,[79] etc. Others, such as the finger ergograph, originally employed by Mosso,[80] *energographs,* recommended by Moede and by Giese,[81] give records of energy output of small muscle groups over a set period of time or until the point of exhaustion is reached.

Chemical tests include numerous devices and techniques for the analysis of the blood; of bodily excretions—particularly of urine[82]—of saliva,[83] to note changes occurring in the course of work.

[77] For a detailed and critical discussion of fatigue tests see V. Dhers, *Les Tests de Fatigue,* Paris, (1924), 185 pages; E. Atzler, *Körper und Arbeit,* Leipzig, (1927), 770 pages.

[78] J. M. Lahy et D. Weinberg, "Variations Inter et Intraindividuelles dans le test du Dynamographe," *VIa Conferència Internacional de Psicotecnica,* Barcelona, (1930), pp. 242–247.

[79] R. A. Spaeth, "Reduction of Unnecessary Fatigue," *Ind. Management,* (Jan.–May, 1920); E. G. Martin, "Tests of Muscular Efficiency," Psych. Rev., 1 (1921), pp. 454 ff.

[80] A. Mosso, *op. cit.*

[81] F. Giese, *Methoden der Wirtschaftspsychologie,* Berlin, (1927), p. 423.

[82] A. Hastings, *op. cit.;* V. Scott, *op. cit.*

[83] A. Durig, *Die Ermüdung,* Vienna, 1914.

Among physiological tests of fatigue may be noted the measurement of rate and amount of oxygen intake,[84] the examination of pulse rate, blood pressure,[85] vascular skin reaction tests, tests of muscular tonus and of reflex activity.[86]

Rate of tapping, accuracy of tapping and dotting, aiming tests, steadiness tests, the measurement of co-ordination by means of the pursuitmeter, tests of oscillation and random muscular movement (restlessness), have been employed to measure *psychophysical* changes occurring in both short and long periods of work both in the laboratory and in the industrial situations.

Mental tests of fatigue, occurring in both muscular and intellectual work, have included simple tests of sensory discrimination, attention tests, measures of memory, imagination, and of the higher mental processes such as intellectual judgment and reasoning.

It is impossible, in the scope of this volume, to include either a description of measures of fatigue or a detailed discussion of the advantages and disadvantages of each. Such a discussion is particularly unnecessary because of the wide variance of opinion among investigators on the suitability and validity of specific tests. Practical difficulties in administration, especially in the industrial situation, interfere with the serviceability of some tests, such as the rate of oxygen intake and amount of carbon dioxide discharge, employed by Imbert [87] and by Hill [88] (Plate VII), which appear satisfactory on many other grounds.[89] Other tests, which can be administered with ease, such as the hand dynamometer,[90] the Piorkowski fatigue-attention meter, give far from consistent and valid results in measuring fatigue and predicting fatiguability.[91]

Physiological and psychological tests of fatigue, in addition to being subject to numerous errors, are influenced by the attitude and will of

the individual to whom they are applied.[92] The problem of devising such measures is complicated by the subjectiveness of the feeling of fatigue and by the marked fluctuations in relationship among subjective state, physiological changes and actual production under different conditions. A better knowledge of the exact relationship and of the factors which influence them is needed before it can be definitely stated that fatigue is the sole variable which is being measured at a given time, under given conditions. In the present state of our knowledge in this field it seems sound to accept, as a working principle, the conclusion drawn by Dhers [93] that, at the present time, fatigue can neither be scientifically isolated nor measured. At the moment, conclusions formulated on the basis of tests as to the degree of fatigue exhibited in specific work represent indirect deductions rather than objective demonstrations; [94] rationalization rather than scientific truth. In testing fatigue we still tend "to measure that of which we have only an inadequate knowledge (fatigue) by procedures which are not altogether valid (tests of fatigue)." [95]

At the same time, as Dhers also points out,[96] the situation is not altogether hopeless. In the first place, general experiments in the field of fatigue and studies of fatigue tests have thrown light on guiding principles which have a theoretical and practical significance. Ergographic studies by Mosso [97] and investigations by Graf,[98] Amberg,[99] Hylan and Kraepelin,[100] Heuman[101] and others have established the recuperative value of rest pauses. Early laboratory studies of "work curves" by Kraepelin [102] are forerunners of more recent investigations of industrial *production* curves. The general uniformity of the human work curve, in spite of complicating factors, favors similar fundamental interpretation of this phenomenon.

The production curve has generally been accepted as the most satisfactory test of fatigue in determining the effect of methods and conditions of work upon the capacity to work. There is a general recognition of the inadequacy of this criterion. It is admitted, as Freeman and

[92] F. S. Lee and J. D. Vanbuskirk, "An Examination of Certain Proposed Tests of Fatigue," *Am. J. Physiol.*, 58 (1923), p. 185 ff.

[93] V. Dhers, "Étude Critique des Tests de Fatigue," *Rev. de la Sci. du Trav.*, 2 (1930), p. 60.

[94] *Ibid.*, p. 62.

[95] *Ibid.*, p. 63.

[96] *Ibid.*, p. 65.

[97] A. Mosso, *op. cit.*

[98] O. Graf, "Über löhnendste Arbeitspausen bei geistiger Arbeit," *Psych. Arb.*, Vol. VII, No. 4, p. 548

[99] Amberg, "Über den Einfluss von Arbeitspausen auf die geistige Leistungsfahigkeit," *Psy. Arb.*, Vol. I, p. 300.

[100] C. Hylan and E. Kraepelin, "Über die Wirkung kurzer Arbeitszeiten," *Psy. Arb.*, Vol. IV, pp. 454–494.

[101] F. Heuman, "Über die Beziehungen zwischen Arbeitsdauer und Pausenwirkung," *Psych. Arb.*, Vol. IV, p. 538.

[102] E. Kraepelin, "Die Arbeitskurve," *Philos. Stud.*, 19 (1902), pp. 459–507; "Über Ermüdungsmessen," *Arch. ges. Psych.*, 1 (1905), pp. 9–30.

Lindley [103] have indicated, that possibly the only justification of this procedure is its convenience. It is also true that use of the production curve introduces difficulties of interpretation, inasmuch, as in the case of the mental and physiological tests, the change in the shape of the curve may be due to factors other than fatigue. Recognition of this fact has led Muscio [104] to recommend that the concept of fatigue be entirely eliminated from the scientific discussion of industrial work. This would still make it possible to use production curves in studying the effects upon human efficiency of specific factors in a diversity of industries and of varied factors in single industries. Changes in the curve, with associated changes in physiological and perhaps even mental functions, would be explained entirely in terms of the varied conditions of production, without reference to the concept of fatigue. The emphasis would be upon the condition producing the change; upon the physiological functions affected; and upon the change in production resulting from the play of diverse working conditions such as hours of work, rest pauses, etc.

However, investigators have been loath to drop the concept of fatigue. The tendency in industrial psychology, as in other fields of psychology, is to use it in explaining the effect of changes in methods and conditions of work. This tendency is reinforced by the acknowledged existence of the subjective state of mind which, in spite of difficulties experienced in its measurement, is very real to the one who experiences it and is easily differentiated by him from other mental states. In view of these facts, the concept of fatigue will be retained in the chapter which follows on the effects of methods and conditions of work. However, the consideration of the material in this chapter must be tempered by a knowledge of the intangible character of fatigue and of limitations of techniques used in its measurement.

[103] G. L. Freeman and S. B. Lindley, "Two Neuro-Muscular Indices of Mental Fatigue," *J. Exp. Psych.*, 14 (1931), pp. 568–569.

[104] B. Muscio, "Is a Fatigue Test Possible?" *Brit. J. Psych.*, 12 (1921), pp. 31 ff.

XXII. THE ELIMINATION OF UNNECESSARY FATIGUE

The discussion of fatigue in the preceding chapter has pointed to the possibility of eliminating unnecessary fatigue in industry. This involves a careful examination of conditions and methods of work for the discovery of those which bring about a useless expenditure of energy.

Contributions toward the elimination of unnecessary fatigue have come from three distinct sources.

1. *The work of the efficiency engineer,* 2. *The study of metabolic changes in fatigue by the physiologist,* 3. *The psychological analysis of work curves and of feelings of fatigue.*

The studies described below will indicate the specific contributions from each of these three fields in increasing efficiency through the elimination of unnecessary fatigue. In the consideration of these studies, as well as in evaluating the contribution from each of the three sources referred to above, the varying connotations of the term "efficiency" must be kept in mind. As ordinarily used this term is made synonymous with production—efficiency being gauged by changes in quantity and, in some instances, quality of output. Efficiency in this sense is strictly an economic concept, and bears no relation to the physiological and psychological costs to the individual responsible for production. Considered in this light, any method or condition of work which brings about the greatest increase in rate of production or in total production, in a given time, may be described as the most efficient method or condition of work.

In contrast with this viewpoint, is the use of the term "efficient" to describe that method or condition of work which favors production at the least physiological cost to the worker and reduces to the minimum the feelings of fatigue and dissatisfaction experienced by the worker at his task. Viewed in this way, one measure of efficiency is the relationship between the energy input and output, that is, the proportion of the energy that is usefully expended. Another criterion, as Thorndike [1] has suggested, is the "satisfyingness" of the task of the worker —the degree of satisfaction derived from the task apart from wages,— measured by the tendency of the individual to relax or abandon the

[1] E. L. Thorndike, "The Curve of Work and the Curve of Satisfyingness," *J. App. Psych.*, 1 (1917), p. 266.

action in question in spite of the fact that the work can be maintained at a constant level of production.

In the analysis of conditions of work the chief interest of industrial psychology is to increase *human efficiency* by decreasing the physiological and psychological cost of work. It is believed that this represents, in the final analysis, the only certain method of permanently increasing *economic efficiency,* but there is a willingness to sacrifice economic values when they clearly conflict with human values.[2] It is this which most clearly distinguishes industrial psychology from scientific management, even where the methods and techniques of the latter have been adopted. There is a pronounced objection to the use of these methods to "increase output at any cost," [3] and an insistence that the physical and psychological criteria of maximum health and maximum satisfaction of the worker—the standard of individual *fitness*—be employed, alongside of output, as a distinct criterion in measuring the effectiveness of any change in conditions of work. Oriented from this viewpoint, as Poffenberger has pointed out, *"the ideal of human efficiency would be the production of maximum output of the highest quality, in the shortest time, with the least expenditure of energy and with the maximum satisfaction."* [4] This viewpoint must be considered in evaluating the data which follows.

1. THE INFLUENCE OF HOURS OF WORK

In the course of the last 30 years American industry has shifted from a working day of 10 hours or more, maintained for 6 full days per week, to a standard day of approximately 8 hours with a half day off on Saturday.[5] This change reflects somewhat the influence of a militant advocacy of a shorter working day by those who feared the debilitating effects of excessive hours upon the health and welfare of the American worker.[6] The acceptance of the shorter working day was facilitated by the demonstration, in the early experiments of Taylor,[7] the Gilbreths,[8] and others,[9] that the shorter working day does not lead to decreased production.

There is practically universal agreement among independent experimenters that average hourly output tends to vary with the length of the working day. This is particularly noticeable when the standard 10 hour day of early years is compared with the standard 8 hour day of the present era. So, for example, a survey of two plants engaged in

[2] H. Rupp, "Die sittliche Verpflichtung der Psychotechnik," *Psychot. Z.*, 5 (1930), p. 105.
[3] E. Farmer, "The Economy of Human Effort in Industry," *J. Nat. Inst. Ind. Psych.*, 1 (1922), p. 18.
[4] A. T. Poffenberger, *Applied Psychology,* New York, 1927, pp. 575.
[5] G. H. Shepard, "Effect of Rest Periods on Production," *Pers. J.*, 4 (1928), p. 186.
[6] J. Goldmark, *Fatigue and Efficiency,* New York, 1912, pp. 893.
[7] F. H. Taylor, *Shop Management,* New York, (1911), pp. 207.
[8] F. B. and L. M. Gilbreth, *Fatigue Study,* New York, 1916, pp. 159.
[9] G. H. Shepard, *op. cit.*, p. 187.

manufacturing the same products showed the average hourly output for the 8 hour day to be 94 per cent of the maximum, and that of the 10 hour day 90.3 per cent.[10] The difference in average hourly output results from a tendency for production during any one period of a spell of work to be controlled by the length of the spell of work or by the total amount of work that remains to be done. This tendency must not be confused with conscious restriction of output. It appears rather to be a non-conscious, in the sense of non-volitional, adaptation of the organism to conditions of work. The tendency to adjust the amount of work to the expected task is well illustrated in a laboratory investigation by Poffenberger [11] who found that, when an individual is instructed to squeeze a hand dynamometer, the effort exerted on each contraction will depend upon the number of contractions which the subject expects to make. In the case of 7 subjects, the average pressure exerted when one contraction was required was found to be 68 kilograms; whereas the pressure for 15 contractions was only 52 kilograms. In both cases the subjects were requested to exert as much pressure as possible.

In another experiment, by Morgan,[12] the lifting time required for raising weights varying from approximately 4 to 13 pounds, was found to remain constant in spite of changes in the weight of the load. This finding suggested that the effect exerted was so adjusted to the size of the load as to keep the lifting time constant. This appeared particularly when the weight of the load was unexpectedly changed. Under these conditions the subject either failed to lift the heavier weight, or applying a great deal of force to a weight which was supposedly heavy, succeeded in lifting it with great ease in very little time. Such experiments suggest that the worker adopts a pace which is "congenial" [13] by dispensing within each short period an amount of energy proportional to the length of time spent at work and to the total amount of work to be done during the day.

The worker not only adapts himself to the length of the working day but also to the length of the working week. A reduction in number of hours, up to a certain point, is associated with an increase in the average hourly output throughout the entire week. In a munition plant a reduction of working hours from 58.2 to 50.6 was followed by an increase in hourly output of 39 per cent. Total output was increased by 21 per cent. In another instance, in the case of women engaged on the moderately heavy work of turning fuse bodies, an increase of hourly output of 68 per cent and a 15 per cent increase of total production followed from a reduction in the number of hours

[10] *Public Health Bulletin, No. 106,* U. S. Public Health Service.

[11] A. T. Poffenberger, *op. cit.*, p. 211.

[12] J. J. B. Morgan, "The Overcoming of Distraction and Other Resistances," *Arch. Psych.*, 35 (1916), pp. 84.

[13] *Ibid.*

from 66 to 48.6 per week.[14] It is interesting to note that in these plants, as in other instances where changes in hours have been made, the beneficial effect of the reduced hours does not appear in full until some months after the change has been made. As Myers has pointed out, "the human organism, after becoming adapted to certain hours of work, requires time, when that adaptation is disturbed, before it can

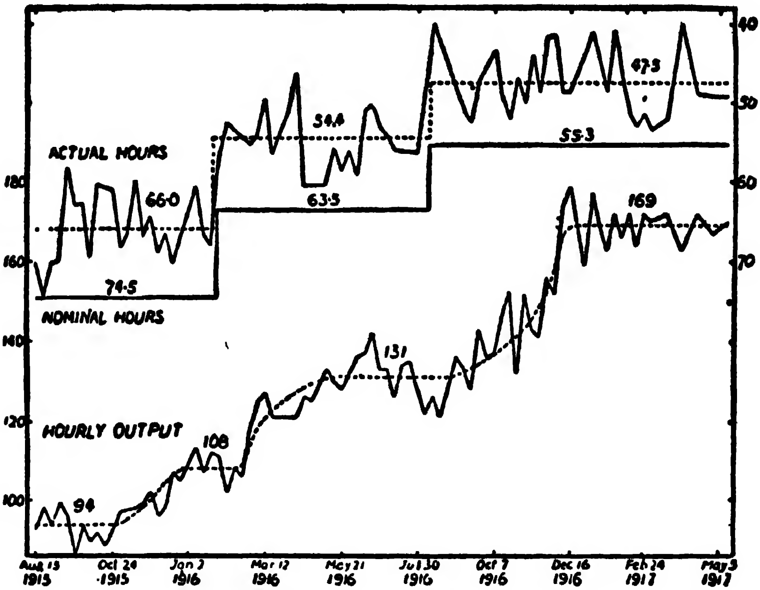


FIGURE 65. *Rate of Adaptation to Changes in Work Schedule Output of Women Turning Fuse Boxes*

(*After Vernon*)

give its maximal response to improved conditions." [15] This holds true not only in connection with changed hours of work but, as will appear in later pages, also with respect to rest pauses and other changes in conditions of work.

The delay in improvement is well illustrated in an investigation [16] of lathe operation (turning fuse bodies) extending over a period of 93 weeks, the findings of which are shown in Figure 65. The top section of the figure shows the number of hours of work and changes in hours of work. The lower curve shows the average hourly production. It is evident that the change in average hourly output, following

[14] C. S. Myers, ***Mind and Work***, London, (1920), pp. 73–76.

[15] *Ibid*, p. 77.

[16] H. M. Vernon, "The Speed of Adaptation of Output to Altered Hours of Work," *Ind. Fat. Res. Bd. Rep.* No. 6, (1920), pp. 33.

a decrease in number of working hours, does not appear until approximately one month after the change is made. In addition, when the change does occur, it represents not a marked increase, but a gradual improvement in output extending over a period of months.

Although hourly production tends to increase with reduced hours of work there is apparently a point of diminishing returns from continued reduction of hours. A study by Wyatt,[17] in the cotton weaving industry, showed that when the working period of a large group of weavers was reduced from 5½ to 4 days, the average hourly output fell off 6 per cent. In the case of 24 laborers and of a group of men engaged in "heel building," or nailing together suitably shaped pieces of leather by means of machines, studied by Vernon and Bedford,[18] it was found that the speed of production reached a maximum at approximately 40 hours a week but decreased with the increase in the length of the working week beyond that point.

A later investigation in a plant manufacturing boxes, by Miles and Angles,[19] reveals similar tendencies. The exact relationships are shown in Table 57. These authors reached the conclusion that the observed relation between rate of production and the hours a week, is influenced by four factors: (a) the dislocation of habitual working pace; (b) the general mental attitude towards continuous short-time (c) incentives arising out of the system of payment; and (d) influence of factory discipline and routine.

TABLE 57

Relation Between Weekly Hours of Work and Speed of Production

HOURS WORKED PER WEEK	NUMBER OF WEEKS WORKED	WEEKLY OUTPUT AND PROBABLE ERROR	HOURLY OUTPUT
36	27	29,926 ± 51.2	834
40	61	34,737 ± 42.7	868
44	31	36,920 ± 89.7	839
48	5	38,100 ± 16.6	793.5

(After Miles and Angles)

Decrease in rate of production with the increase of working hours beyond 40 is explained in terms of fatigue. The decrease in the rate of output with the shorter time is explained by investigators as a result of loss of skill entailed by an extended rest from work. There is likewise an increase in the time required for "warming up" at the beginning of the next period of work. Voluntary restriction of output

in the case of short-time work is also suggested as a possible influence.

In view of these facts, shortened time as a means of combating unemployment may prove to be, from the viewpoint of the individual plant, an uneconomical remedy.[20] From the standpoint of plant efficiency, it is probably more economical to keep half the force engaged for the normal hours of work throughout the week than to retain all workers on half time basis. The loss of skill and the prolonged period of incitement and settlement associated with the longer interval of rest tend to diminish the hourly rate of production during the periods when the worker is engaged at work. In addition, in the shortened work week there appears an incentive for restriction of output, as a means of prolonging the work and of providing opportunities for employment of other workers, which is absent when the employee is engaged throughout the entire week. However, in the individual plant the significance of this observation must be balanced against the broader social values to be achieved through the continued employment on a short-time basis of a larger working force.

This analysis of the relation between hours of work and production suggests the need of a more careful study of the optimal length of the working day and working week. As Lee has indicated, "operations differ greatly, and one is treading on dangerous ground if he attempts to predict an optimal working day without an analysis of the work itself."[21] Lipmann[22] has used the term *economic optimal work day* to describe that well defined period of time, differing with respect to different work and different workers, in which the capacity for production is so maintained that the value of goods produced is maximum for the cost of wages, current, light, heat, and overhead expenses. He has developed formulae for calculating the length of this day under different conditions.

Applying these formulae, Lipmann has computed the *economic optimal working day* in 234 cases representing diverse industries in 18 countries, in which he had complete data concerning changes in working hours and production. He has chosen only cases in which the difference between the time periods is only in length of working days, and in which the production was not estimated but exactly measured. Moreover, in the cases shown, the hourly production in the shorter working day was in every instance higher than that in the longer working day. The findings showed that in 46 cases the *optimal working day* is longer than the longer of the two working periods; in 39 cases it is between the two; and in 147 cases it is shorter than the shorter of the two working days. The middle 50 per cent of *optimal working days* was found to be between 6½ and 10 hours; the middle 50 per cent of *optimal working weeks* between 33 and 48 hours.

The optimum working day was found to differ in different industries. For example, it lies between 5.8 and 6.1 in the glass and procelain industry with a median of 5.9 hours; between 7.2 and 7.7 with a median of 7.4 in the tool-making industry; between 10.5 and 13.6 with a median of 11.9 in the textile industry, etc.

A comparison of workers in the same field also showed that the optimal time is longest for workers between 30 and 35 years of age, and shortest for those between 20 and 25 years of age. The *economic optimal working day* is higher in most cases for the most capable workers. In other words, productive capacity is to be identified with lower fatiguability. The optimum working days for different workers in the same field range, for example, between 8.5 and 18.5, 8.9 and 17.3, 5.8 and 13.2; etc.

Lipmann suggests that there can be no single length of working day optimal for all industries, all departments of a plant, all workers, or all countries, and questions the position of the exponents of a universal eight hour or shorter working day. He concludes that although the eight hour or shorter working day may be desirable on cultural and other grounds, it is far from adequate in satisfying the economic needs and in maintaining the optimum physiological balance of the worker in many industries.

The validity of the formulae employed by Lipmann is in need of more extended empirical verification. The problem is tremendously complicated by the inadequacy of our knowledge concerning the most desirable limits of physiological cost; the use of leisure time by workers; relation between length of working period and the "satisfyingness" of work; practical difficulties in the administration of working periods of varying length in the same plant; etc. However, the approach is suggestive, particularly in its emphasis on the importance of considering the specific conditions existing within a single plant and affecting the individual workers. In this respect it reflects the concern for individual adjustment which is the chief characteristic of sound psychological investigations in industry.

2. THE INFLUENCE OF REST PAUSES

Production and fatigue are influenced not only by hours of work but by the opportunity provided for rest in the course of work. The findings of early laboratory investigations with ergograph and with curves of manual and mental work agree with those of early plant studies by efficiency engineers in the demonstration that, in general, "more output can be achieved by applying oneself steadily for short periods, and then resting, than by applying oneself less steadily and having no rest periods." [28] Rest pauses have been almost universally

[28] F. B. and L. M. Gilbreth, *op. cit.*, p. 40.

accepted by industry as an aid in increasing production and in reducing fatigue.

The authorized rest pause does not constitute a complete change from ordinary methods of working, inasmuch as even under ordinary conditions workers accommodate themselves to "the law of maximum production with minimum effort," [24] and manage to find ways of stealing rests in case authorized rests are not allowed. As a matter of fact, unauthorized rests may be taken in accordance with a regular schedule established by the workers themselves, as appears in the plant referred to by Hersey [25] in which 5 men, working on finishing machines, made a practice of leaving the machines one by one every morning after working about two to two and one-half hours, and from 3:15 to 3:45 in the afternoons, to spend 15 or 20 minutes in the only rest room available, the toilet. Vernon has shown that men and women engaged in active work in a munition plant may spend 7 to 8 minutes each hour in voluntary rests, while women engaged in passively watching machines may spend 3.7 minutes each hour at rest. [26] The same investigator found that men working in the manufacture of tin plate averaged 10.2 minutes in voluntary rest on 6 hour shifts and 12.5 minutes per hour when working on 8 hour shifts.[27] Men employed in moderately heavy work such as agriculture and road making, paid on a time basis, spend approximately 11 minutes of each hour at rest. In heavier work such as loading pitch, the proportion of voluntary rest to work was found to be much greater. Similar tendencies appear in the case of piece rate workers, although they are not as marked.[28]

Other instances of unauthorized rest pauses are cited both by these authors and by other investigators in this field. There is a general agreement that, in many instances, the authorized rest period is in fact only a substitute for unauthorized rest and actually takes no more time out of the day's work. At the same time, the authorized rest, placed at the most effective points of the working day, almost invariably produces increased production. It serves better than the voluntary rest the purpose of providing the worker the relaxation which he needs, at the time he needs it, to recover from the effects of continued work. It better accomplishes this purpose, in part, because the worker can lie down, or relax in other ways, free from the strain associated with the fear of censure if discovered by the foreman or supervisor away from his bench or machine.

The effectiveness of the scheduled rest pause in increasing production has been illustrated in numerous investigations. Characteristic

of these is the study by Vernon and Bedford [29] of 17 girls employed in labelling. A comparison of average hourly output during 20 weeks subsequent to the introduction of a 10 minute rest pause in the middle of the morning with a 20 week period without rest pauses showed a 20 per cent increase in hourly average production, in spite of a 2 per cent decrease in working time following the introduction of the rest pause. Another investigation by the same authors, involving 7 girls engaged in assembling bicycle chains who were observed for 60 weeks, showed an increase of 13 per cent in average hourly output subsequent to the introduction of a five minute rest period per hour.[30] Increases in output from 3.6 to 24.0 per cent are reported by Efimoff and Zibakowa to have followed the introduction of 5 minutes of rest following every 50 minutes of work in a metal plant. In Russian textile and candy plants, according to Ermanski,[31] increases in production up to 25 per cent resulted from breaking up work by 5 minute pauses at the end of every hour of work and of 15 minutes at the end of one and one-quarter hours. Frois and Caubet refer to equally satisfactory results in filling bombs in munition plants, when 2 minutes of rest were allowed after every 3 minutes of work.[32]

In the introduction of rest pauses, as in changing the hours of work, a period of time is required for the readjustment of the organism to the new working conditions. The pace established for the uninterrupted working day continues for sometime after the rest pauses have been introduced and the day has been shortened. It is also gradually that the psycho-physiological mechanism takes on increased speed and exerts greater effort in adjustment to the interruptions in work, as to decreased hours, in order to maintain a total production and an expenditure that is constant for the working situation. This fact is of particular significance to industrial managers and others who may feel discouraged because of the failure of a change in conditions to produce immediately an increase in hourly average output.

Confirmatory evidence on the value of rest pauses in increasing production is found in a recent study [33] conducted at the Hawthorne Works of the Western Electric Company which extended over a period of more than 2 years. Constant observations under different experimental conditions were made on a group of 5 women engaged in the repetitive work of assembling telephone relays. This consists of putting

[29] H. M. Vernon and T. Bedford, "The Influence of Rest Pauses on Light Industrial Work, *Ind. Fat. Res. Brd. Rep.* No. 25, (1924), pp. 1–20.

[30] In this investigation, as in others, it is not altogether clear whether the improvement is due to the opportunity accorded by the rest period for recovering from fatigue, or whether it is due to other factors discussed in the chapters on monotony. However, with the production curve as a criterion, it can perhaps be assumed that the improvement is at least in part due to recovery from fatigue.

[31] Cited from W. Richter, "Leistungssteigerungen in der Blankschraubenfabrikation durch Einführung von Zwangspausen," *Ind. Psychot.*, 8 (1931), pp. 129–146.

[32] Cited from W. Richter, *ibid.*, p. 131.

[33] G. A. Pennock, "Industrial Research at Hawthorne," *Pers. J.*, 8 (1930). 296–313.

together a coil, armature, contact springs, and insulators in a fixture and securing the parts in position by means of 4 machine screws. This operation can be done at the rate of about 1 assembly a minute.[84]

The first step of the study was to remove 5 experienced girls who had been informed of the purposes of the experiment to a special test room established in a corner of a regular shop room. Information on the amount of sleep, recreations, home conditions, as well as records of observations made on the workers in the plant were maintained. Pulse rate, blood pressure, blood condition readings, vascular skin reactions and other physical examination data were obtained from time to time.

Accurate records of production from instant to instant were maintained by means of an electric device recording the completion of each relay as it passed out of a chute into which it was dropped by the operator. As a basis of comparison a record of output for 2 weeks in her regular department was kept for each test operator (without her knowledge) before she was moved to the test room. After being moved to the test room no change in conditions of work was made for a period of 5 weeks, a record of output being kept during this period. It is interesting to note that there was no appreciable change in output following this move.

The first innovation in conditions of work was a change in method of payment, the operators being placed on a group piece rate base salary independent of the large group with which they were previously identified. Following this a series of changes in working conditions, consisting chiefly of variations in the length and position of rest pauses, was introduced. The character of these changes and the period of time of each is shown in Table 58.

The most significant feature of the experiment is the finding that the productivity of the test group tended in general to increase regardless of the nature of changes in working conditions introduced. The general trend is evident in Figure 66. For some operatives this increase ran as high as 35 to 50 per cent. The highest productivity was recorded in Period 13 during which the operators had a 15 minute rest and lunch period in the morning and a 10 minute rest period in the afternoon. The "unexpected and continual" [85] upward trend in productivity was found even in Period 12, when the girls were put on a full 48-hour week with no rest pauses and no lunch. This latter finding is presented as partial evidence that *the most important influence in increasing output when rest pauses are introduced is not the relief from fatigue but the change in the mental attitude of the workers in the test group, particularly with respect to supervision.* According to the investigators,

[84] This study was part of a more extensive investigation on the desirability of rest periods, on the effect of wrong and right methods of supervision, and on factors determining employees' mental attitude conducted by Western Electric Company, further reference to which will be found in other chapters of this volume.

[85] *Ibid.*, p. 304.

"a relationship of confidence and friendliness has been established with these girls to such an extent that practically no supervision is required. In the absence of any drive or urge whatsoever they can be depended upon to do their best. They say they have no sensation of

TABLE 58

Summary of Test Periods, Relay Assembly Group (see Figure 66)

PERIOD NUMBER	PERIOD NAME	DATES INCLUDED	DURATION	BEGINNING OF REST PAUSES A. M.	P. M.
		1927			
			weeks		
1	In regular department	4–25 to 5–10	2 *	None	
2	Introduction to test room	5–10 to 6–11	5	None	
3	Special gang rate	6–13 to 8–6	8	None	
4	Two 5-minute rests	8–8 to 9–10	5	10:00	2:00
5	Two 10-minute rests	9–12 to 10–8	4	10:00	2:00
6	Six 5-minute rests	10–10 to 11–5	4	8:45, 10:00, 11:20	2:00, 3:15, 4:20
7	15-minute A. M. lunch 10-minute P. M. rest	11–7 to 1–21–28	11	9:30	2:30
		1928			
8	Same as No. 7, but 4:30 stop	1–23 to 3–10	7	9:30	2:30
9	Same as No. 7, but 4:00 stop	3–12 to 4–7	4	9:30	2:30
10	Same as No. 7 (check)	4–9 to 6–30	12	9:30	2:30
11	Same as No. 7, but Saturday A. M. off	7–2 to 9–1	9	9:30	2:30
12	Same as No. 3 (no lunch or rests)	9–3 to 11–24	12	None	
		1929			
13	Same as No. 7, but operators furnish own lunch. Company furnishes beverages	11–26–28 to 6–29	31	9:30	2:30
14	Same as No. 11	7–1 to 8–31	9	9:30	2:30
15	Same as No. 7, except operators furnish own lunch. Company furnishes beverages	9–2 to present		9:30	2:30

* Approximately.

(After Pennock)

working faster now than under the previous conditions, and that their greatly increased production has been accomplished without any conscious effort on their part. Comment after comment from the girls indicates that they have been relieved of the nervous tension under which they previously worked. They have ceased to regard the man in charge as a 'boss'— They have a feeling that their increased produc-

tion is in some way related to the distinctly freer, happier, and more pleasant working environment."[36]

In confirmation of the opinion that fatigue is of no significance the following facts are cited:

(a) Weekly production curves of operators do not show a decline

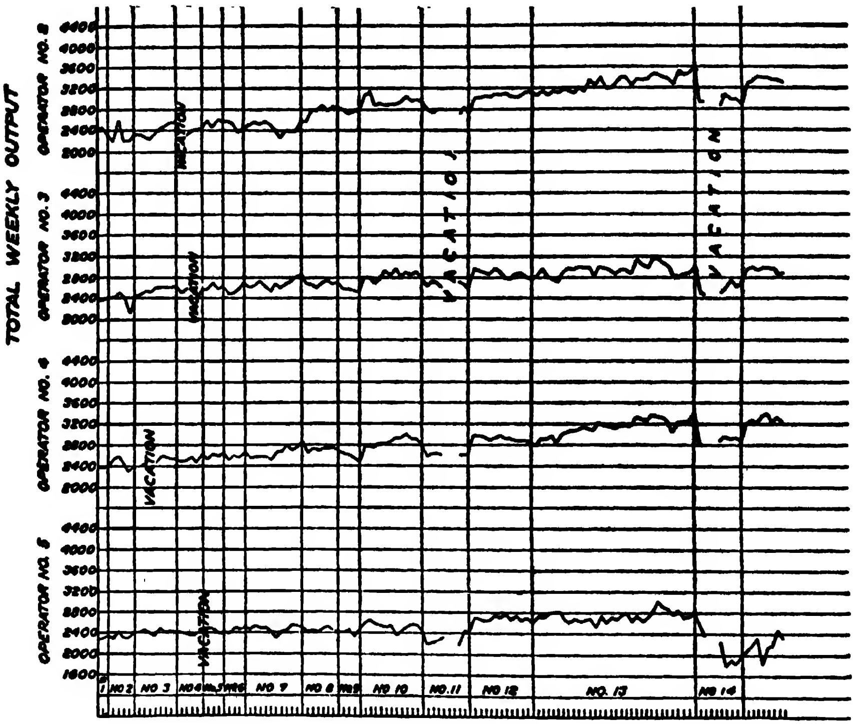


FIGURE 66. *The Performance Curves for Each Operator and for the Group Showing the Weekly Variations in Productivity since the Relay Assembly Test Began*

Periods of the test are separated by the vertical lines. The test conditions in each period are shown in Table 58.

(*After Pennock*)

in daily production during the latter days of the week.

(b) Vascular skin reaction records show no increase in fatigue.

(c) Gradually rising production over a period of 2 years indicates the lack of cumulative muscular fatigue.

(d) Regular physical examinations show that the health status of the girls in the test room is being more satisfactorily maintained than

[36] *Ibid.*, p. 309.

that of girls in the regular department. There are also less illness and fewer absences among the former.

It is interesting to note that the arguments stated under c and d are exactly the same used by other investigators in illustrating the effectiveness of rest pauses by *reason of reduced fatigue.* The validity of this vascular skin reaction test as an index of fatigue remains to be confirmed. The authors fail to present weekly production curves, but it is quite possible that there exists a typical variation of the type found in the monotony curve, and that the improvement may follow from a relief from monotony alone instead of from the improved attitude toward the supervisor upon which the investigators place so much stress.

In connection with the experimental studies the records were obtained on number of hours of sleep. These records show that the amount of sleep has a significant effect upon individual performance, evidence which might very well be cited in favor of the fatigue hypothesis but to which the investigators make no reference in discussing their hypothesis of mental attitude. No reference is made to the significance of slow adaptation to rest pause which results in a cumulative effect on production of the rest pause. The superior increase in production noted in Period 13 may, for example, simply be due to the fact that observations in connection with this change were continued over a period of 31 weeks, a period almost three times as long as any other observed. Slow adaptation to changes may also account for the findings in Period 12. As a matter of fact, a study of the curves shows that the rise in productivity during this period was not as marked as in Period 13 and that, in a few cases, there is a tendency toward a drop in production at the end of the Period 12, a drop which, because of the slow adaptation to negative as well as positive changes in conditions of work, would naturally be expected only toward the end of this period of change.

Data showing the favorable effect of rest pauses in other shop departments in which no other changes in conditions of work were made is presented in this report. These are not as marked as those occurring in the test room, but the fact that rest pauses do increase production on the part of those workers, combined with the other evidence presented above, suggests that there is an unwarranted emphasis by this group of investigators in their conclusion that "the mental attitude of the operator toward the supervisor and working and home conditions is probably the largest single factor governing the employees' efficiency." [87]

The Duration and Location of the Rest Pause

Many investigations have shown that the length and position of the optimal rest pause depend upon the nature of the work, the length of

[87] *Ibid.*, p. 311.

the working day, and upon similar factors affecting production and fatigue. Incitement tends to augment working capacity, whereas fatigue has the opposite effect. The most favorable rest pause is one which will conserve all the benefits of incitement and at the same time eliminate fatigue as much as possible.[38] Under these conditions too long a rest may be unfavorable because of the loss of incitement or warming up entailed in the long period away from work.

There are a number of laboratory investigations bearing upon the optimal length of the rest pause. The earliest of these are concerned primarily with mental work. So for example, Graf,[39] by introducing rests of ½, 2 and 5 minutes' duration in a 40-minute period of mental addition, discovered that the 2-minute rest was most beneficial. When work extended for 80 minutes, a 5 minute rest pause was found to be the most desirable. Amberg [40] found that whereas a pause of 5 minutes showed a favorable influence on production, a pause of 15 minutes introduced half-way in a work period of one hour had an unfavorable effect on production.

There are a few more recent experiments dealing primarily with muscular activities. Among these is a recent investigation at Purdue University,[41] designed to determine the minimum proportion of rest periods to total working hours which should be introduced to obtain a maximum output on the part of workers engaged in light-heavy muscular work. Light-heavy work was defined as that in which "the muscular system is continually under load during the operation, the load not being heavy enough to produce a sensation of muscle strain, but repeated so many times that the worker becomes sensibly fatigued by the end of the day's work." [42] It is important to emphasize that the object of this experiment was not to determine the best proportion of rest periods, but the *minimum,* in the sense that any diminution of rest would unquestionably produce a decrease in output.

The subjects of the experiment were 6 healthy male students of superior physique employed to work on a gymnasium chest weight machine, the operator being required to raise and lower the weights by walking from and toward the machine. He faced the machine and raised his arms before him as he approached the machine until the weights struck the bottom stops, throwing his arms behind him until the weight struck the top stops. Each subject was required to make an all-day run of approximately 8 hours once a week, for a period of 5 to 8 weeks. When working at the test the operator was paid a bonus,

[38] S. Wyatt, "Rest Pauses in Industry," *Ind. Fat. Res. Brd. Rep.* No. 42, (1927), p. 4.

[39] O. Graf, "Über lohnendste Arbeits Pausen bei geistiger Arbeit," *Psych. Arbeiten,* 7, p. 458.

[40] Amberg, "Über den Einfluss von Arbeitspausen auf die geistige Leistungsfähigkeit," *Psych. Arbeiten,* 1, p. 300.

[41] G. H. Shepard, "Effect of Rest Periods on Production," *Pers. J.,* 7 (1928), pages 186–202. This investigation follows upon a preliminary experiment by the same author reported in "Experiments at Purdue University," *Ind. Mgt.,* 42 (1921), pp. 281 ff.; 43, pp. 354 ff.

[42] *Ibid.,* p. 187.

similar to the Emerson efficiency bonus, in addition to time rates. Inasmuch as all operators were dependent at least in part on work for support, the pay, and more particularly the bonus, represented a material incentive to work.

During rest periods the workers were required to lie down and relax completely under blankets on cots provided for that purpose. Each operator was required to spend 19 hours at rest immediately preceding the day's run. Under these conditions it is found that the worker can not give his maximum output unless he rests approximately 16.6 per cent of the time during working hours. The author points out that this percentage is practically the same as the practice of the U. S. Army in marching infantry, arrived at by a gradual evolutionary process.[43] It also conforms to the results obtained by Amar who, after standardizing conditions and methods of work in filing brass with a half round file, concludes that "the operation should continue five minutes and be followed by one minute of complete rest." [44] It also agrees with the proportion of rest empirically established as satisfactory in an early investigation on handkerchief folding by Gilbreth.

Among the most significant of Shepard's findings is the observation that the subjects of this study were able, after instructions and experience, to select the most satisfactory work and rest periods under the guidance of their own feelings. The fact that the subjects of this experiment were college students of superior intelligence, combined with the more exact control of the conditions of work, may make this finding inapplicable to industrial workers. However, the determination that workers can be taught to work and rest under the guidance of their own feelings as efficiently as an industrial engineer or industrial psychologist can guide them, on the basis of test data, would be of utmost significance in industrial work and warrants very complete examination in the industrial situation.

Such laboratory investigations, as well as the earlier studies by Kraepelin, Amberg, Graf, etc., are of unquestionable value in setting up general principles for the distribution of rest pauses. However, because of the differences in the energy cost of specific jobs and of diverse working conditions, the most satisfactory results in increasing production and reducing fatigue can only be obtained by the experimental determination of the effects of various rest pauses under plant conditions. The importance of this procedure is well illustrated in a study of rest pauses in a German machine shop by Richter. [45]

The subjects were women employed in the manufacture of screws, bolts, and nuts. The working day extended from 7 A. M. to 4 P. M., and was divided into 3 spells by a breakfast period extending from 9:30 to 9:45 and by a 45-minute break for lunch at 12:00. Throughout

[43] G. H. Shepard, *op. cit.*, p. 192.
[44] Cited from G. H. Shepard, *op. cit.*, p. 194.
[45] W. Richter, *op. cit.*

the course of the experiment production records were taken at 15-minute intervals. The procedure and findings of this experiment can be illustrated by reference to the determination of the optimal length and distribution of rest pauses in the case of women employed in cutting threads on brass parts. The experiment extended over a period of 6 weeks and included 5 subjects. The typical daily work curve prior to introduction of rest pauses is shown in the top section of Figure 67. The curve of production is typical in showing a gradual increase in rate at the beginning of the work spell, a maximum point following approximately the third hour of work, and a rapid and consistent drop throughout the major portion of the afternoon spell of work.[46]

Preliminary experiments demonstrated clearly that satisfactory results could not be obtained by arbitrarily introducing the rest pause in the middle of work spell or by arbitrarily determining the positions in the work spell. Careful observations indicated that the most satisfactory results could be obtained by an examination of the work curve and by the introduction of the rest pause approximately 10 or 15 minutes after the work curve had achieved its maximum, in other words, shortly after the curve of work starts to fall. Placing the rest pause at this position apparently makes it possible to lose none of the advantages of incitement and settlement, and at the same time to avoid continuing work beyond the point at which there results an excessive accumulation of fatigue.

This experimental finding is in agreement with the conclusion reached by Wyatt that the rest pause should be introduced at about the time output reaches its maximum. "At this stage working activity is about to decrease, and the recuperative effects of the pause will retard the on-set of factors detrimental to output and tend to maintain working activity at a high level during the remainder of the spell." [47] In the case of multiple rest pauses in the same working spell, the evidence pointed to the desirability of placing additional rest pauses at the point at which the curve, after the introduction of the initial rest pause, again started to fall.

The actual results obtained through the introduction of a diverse number of rest pauses of varied length, in the case of workers engaged in thread cutting, is shown in Figure 67. It is evident that there is the greatest decrease in the variability of rate of work with the introduction of 6 rest pauses each 2 minutes in length placed at a point in the curve in accordance with the principles described above (b). It is also interesting to note that this number and distribution of rest pauses, involving a total loss of 12 minutes of work a day, produces an increase of production of 6.03 per cent, whereas a total rest of 15 minutes

[46] The curve is atypical in its resemblance to the so-called monotony curve in the drop in the middle of the morning spell. However, it is typical in the absence of the drop in the middle of the remaining working spells and in its failure to show the spurt at the end of each spell of work, to be expected in the monotony curve. (See Chapter XXIII.)

[47] S. Wyatt, "Rest Pauses in Industry," *Ind. Fat. Res. Bd. Rep.* No. 42 (1927), pp. 2–3.

divided into three pauses each 5 (e) minutes in length, results in a decrease in production of 2.61 per cent.

For purposes of comparison, there are shown, in Figure 68, the results obtained in the case of 4 experienced women employed in slitting the heads of brass screws, whose work records were obtained for a period of 5 weeks. The most advantageous distribution of work periods

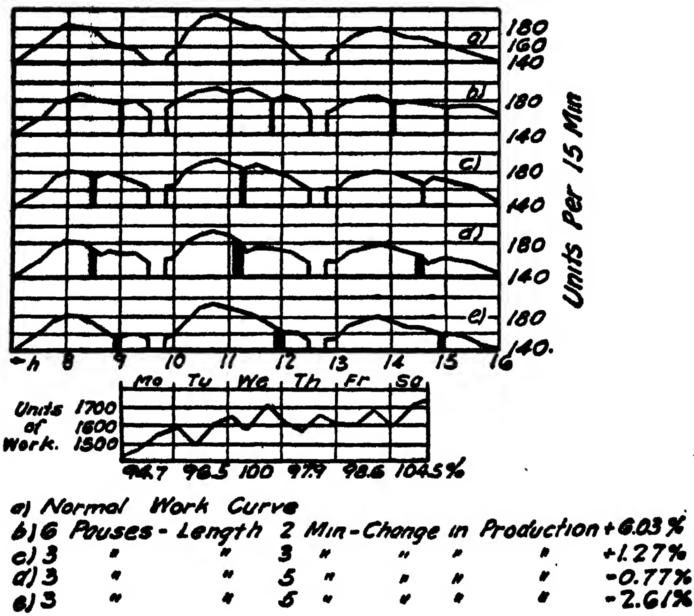


FIGURE 67. *The Effect of Rest Pauses of Varied Length Upon Output*
(*After Richter*)

in this case turned out to be 6 pauses, each 3 minutes in length, which produced an average increase in production of 11.01 per cent (b). The introduction of 24 minutes of rest divided into 3 pauses each 8 minutes in length resulted in a decrease in production of 5.58 per cent (e).

There are, unfortunately, too few investigations of this type. The results demonstrate a fact that has often been neglected in the study of rest pauses—that an improper distribution of rest pauses may result in a *decrease* of production without reducing fatigue by offsetting the effects of "practice," and by breaking into the "warming up" period, during which the effects of fatigue are not of particular importance. The differences in the distribution of advantageous pauses for various kinds of work observed in this investigation are evidence that the results obtained in one kind of work cannot be directly ap-

plied to other kinds of work. As Richter[48] points out, the productive value of the rest pause depends on

(a) Kind of work
(b) The type of worker employed
(c) Location of the rest pause
(d) The length of the rest pause
(e) The day of the week
(f) The shape of the work curve.

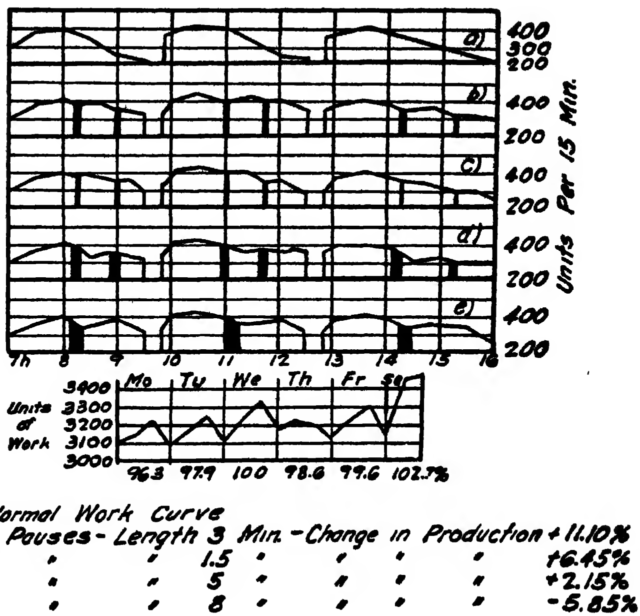


FIGURE 68. *The Effect of Rest Pauses of Varied Length Upon Output (After Richter)*

An experimental analysis of the effect of each of these conditions furnishes the only scientific basis for establishing the effectiveness of the rest pause in a specific industrial situation.

Relaxation in the Rest Pauses

Associated with the question of the length and distribution of the rest pause is that of how the rest pause should be spent. Mayo[49] and Hersey[50] have insisted that the authorized rest period can give the best results if the worker is induced to spend it in complete muscular

[48] W. Richter, *op. cit.*, p. 141.
[49] E. Mayo, "Revery and Industrial Fatigue," *J. Pers. Res.*, 5 (1924), pp. 273–81.
[50] R. B. Hersey, *op. cit.*, p. 44.

relaxation, actually endeavoring, as a matter of fact, to fall asleep during the rest pause. In one plant where this method of complete relaxation was introduced, it proved so satisfactory that Army cots were bought by the management to take the place of sacks filled with cotton or wool, which were first used. Although this method is probably desirable in cases of heavy muscular work, it is equally true that under other conditions the rest period can be spent to better advantage in some form of recreation or perhaps even in a strenuous activity which involves other muscles and other objectives than the work itself. This is particularly true where the work is highly repetitive in character, and where decreased production is associated with the feeling of monotony rather than true fatigue.[51] It is also unlikely, as Mayo has insisted, that the benefits of relaxation grow out of the discouragement of irrational reveries and pessimistic day-dreams.[52] It seems unnecessary to introduce this concept into the explanation of the situation which can be more easily and more simply explained in terms of physiological processes involved in fatigue.

3. EYE STRAIN AND FATIGUE

(a) The Influence of Illumination

Defective illumination is a major factor in unnecessarily increasing fatigue resulting from work. Investigations have shown that in certain types of work output falls and the feeling of weariness increases as a result of defective lighting. This is particularly evident in the change from daylight to artificial illumination, because "the eye sees its object much more quickly, sustains its power of clear seeing very much better, fatigues less quickly and suffers less discomfort under daylight intensities than under those found in artificial lighting." [53]

Changes in illumination are expressed in terms of the *foot-candle*. The foot-candle represents the intensity of illumination upon a surface one foot from a standard candle (that is, a candle about one inch in diameter), when the surface is held perpendicular to the direction of light from the source. The intensity of illumination outdoors on a clear mid-summer day sometimes reaches 10,000 foot-candles.[54] The intensity of illumination on the ground shaded by a small tree is ordinarily as high as 1000 foot-candles. This is ofttimes considered as the ideal intensity of illumination. The average intensity of illumination of large indoor areas is generally about 10 foot-candles. The intensity of artificial illumination indoors is often not as high as this, and a large

[51] See discussion of rest pause in monotonous work in Chapter XXIV, pages 554–55.
[52] E. Mayo, *op. cit.*
[53] C. E. Ferree and G. Rand, "The Ocular Principles in Lighting," *Trans. Illum. Eng.*, 20 (1925), p. 278.
[54] M. Luckiesh and F. K. Moss, *Seeing*, Baltimore, (1932), p. 6.

proportion of individuals working in offices and factories do their work with an intensity of illumination of about 3 foot-candles.

Muscular movements take place when the eyes are in use. The eye regulates, by means of changes in the *size of the pupil,* the amount of light falling on the retina, its sensitive surface. Activity of muscles of *accommodation* is involved in focussing with respect to the distance of the object which is being observed. Additional muscular movements are involved in maintaining ocular balance as both eyes are *converged* upon a single object.[55] The amount of such movement may be considerably increased when the conditions of illumination are unsatisfactory. So, for example, shiny points or surfaces on a black machine, producing reflected glare, bring about excessive muscular movement, accompanied by a pronounced feeling of strain, as visual attention is diverted from the dark background to the polished surface and as the pupil attempts to adapt itself to the widely differing intensities of illumination. In addition to unevenness of illumination, insufficiency of light and inconstancy of illumination increase the difficulty of seeing and produce eye strain and fatigue, which are oftimes reflected in headaches and a general feeling of malaise.

It is not possible to measure quantitatively the amount of fatigue produced by the use of the eyes under unsatisfactory conditions of illumination,[56] although Goldstern [57] finds objective evidence of visual fatigue in the periodic oscillation of fatigue and recovery phenomena observed in 20 subjects, when the amount of errors in measurement on the polarimeter is used as an index of visual efficiency. However, when it is borne in mind that adults use their eyes about 16 hours each day, that approximately 70 per cent of muscle activity is due to impulses received through the eyes, it becomes evident that an environment that makes difficult the use of the eyes will contribute enormously to fatigue. A survey of 21 common industrial and office activities has shown that the eyes are engaged in serious work 70 per cent of the time. The failure to provide proper lighting must increase considerably the consumption of bodily energy during this major portion of the day's work.

The influence of increased strain when eyes are employed under unsatisfactory lighting conditions is not limited to increased energy expenditure. It also appears, as Luckiesh and Moss,[58] and Ferree and Rand [59] have suggested, that a pleasantly lighted room helps directly to create agreeable affective tones, whereas a dark, gloomy workroom may provoke opposing states of mind. Dim lighting promotes relaxation, whereas a brightly lighted environment stimulates the individual toward increased activity without increasing excessively the energy

expended in the work. Evidence of the stimulating effect of light, even when it is not directly involved in the work which is being done, is found in one laboratory investigation, where an increase of 8 per cent in the amount of work done solely by touch was noted when light was permitted to enter the eyes through frosted goggles, over that done when the room was in darkness.[60]

The influence of better lighting upon efficiency in industry has been

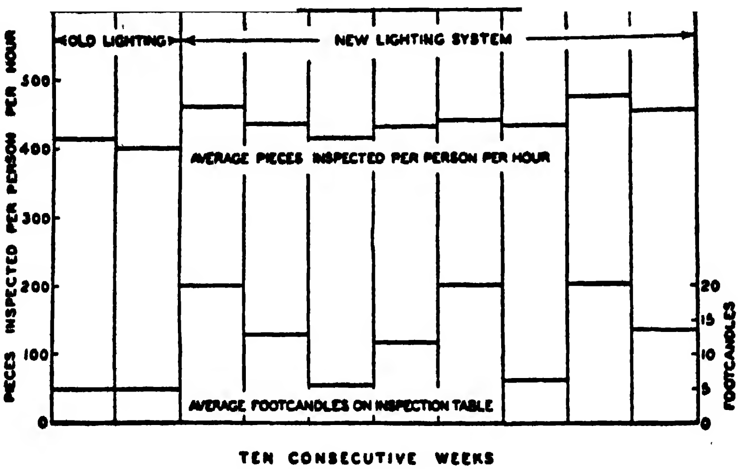


FIGURE 69. *Effect of Changes in Illumination Upon Production*

Showing the average number of pieces of material inspected per person per hour for each of ten consecutive weeks; also the corresponding intensities of illumination for the various weeks. During the first two weeks the old lighting system (half daylight) was in operation. During the remaining eight weeks the new system of artificial lighting was operated.

(From an Investigation Conducted by Hess and Harrison—After Luckiesh and Moss)

investigated both in the laboratory and in industry. Characteristic of the industrial studies is an investigation conducted by Hess and Harrison[61] in the inspection department of an industrial plant. The work consisted of examining parts of a roller bearing turned out by automatic screw-machines. The investigation was conducted under actual working conditions with as little disturbance to factory routine as possible. Thirty-eight to 48 inspectors, paid on an hourly basis were involved in the study, which extended over a period of 10 weeks, during which changes were made in the intensity of illumination at various times.

[60] M. Luckiesh and F. K. Moss, *op. cit.*

[61] D. P. Hess and W. Harrison, "Relation of Illumination to Production," *Trans. I. E. S.*, 18 (1923), pages 787 ff.

The results of this study, shown graphically in Figure 69, reveal a high correlation between the amount of work produced and the intensity of illumination. This finding is made particularly significant by the fact that the workers were paid on an hourly basis throughout the course of the investigation. There was no change in the incentive toward production, or in any other condition other than illumination, to account for the increase of production at various times. It is also of interest to note, that in the case of every increase in illumination the cost of improved lighting was below the value of the increased output obtained by the better lighting.

Similar results are reported in a series of studies by the *Industrial Fatigue Research Board*. In one experiment, for example, the work of compositors in a printing plant was observed (1) under daylight and (2) under properly distributed artificial light, of varied intensity.[62] At an illumination of 2 foot-candles there appeared a 25 per cent loss of output and a 10 per cent increase of errors over those made under daylight conditions. At 7 foot-candles there occurred a 10 per cent output loss and only a slight increase of errors over those made with daylight illumination. With an illumination of 20 foot-candles the daylight rate of work and the daylight accuracy was maintained.

A 6 per cent increase in the output of 5 women tile pressers with an increase in average of illumination of from 1.7 foot-candles to 4.7 foot-candles, is reported by Weston and Adams.[63] Removal of the workers to a shop having good daylight illumination resulted in a further 6 per cent increase in output. In addition, the feeling tone of the workers appeared to be considerably improved by provision of better lighting conditions.

The relationship between illumination and visual acuity and ocular fatigue, has been examined by Ives of the United States Public Health Service.[64] The investigation was conducted with post office employees engaged in the routine sorting of mail. Changes in visual acuity associated with changes in level of illumination was chosen as the criterion for evaluating the effects of illumination upon the welfare and efficiency of the worker. The investigation, which extended for more than a year, was divided into 7 periods, the intensity of the illumination at the work place being changed in each period. The visual acuity of each worker was measured at the beginning and close of each day's work by means of the International Test Chart. Results are summarized in Table 59. It is evident that acuity varies directly with the intensity of illumination. There is reason for believing that the higher level of illumination, by increasing the visual acuity, makes easier the task of

[62] L. A. Legros and H. E. Weston, "On the Design of Machinery in Relationship to the Operator," *Ind. Fat. Res. Bd., Report* No. 36 (1926), pp. 34.
[63] *Tenth Annual Report*, "Ind. Fat. Res. Bd.," London, (1930), p. 7.
[64] J. E. Ives, "Study in Illumination," *U. S. Public Health Bulletin*, No. 181.

sorting mail and decreases the ocular strain or fatigue involved in this work.

An interesting finding of this study is that the visual acuity varies in the course of a day's work, and that the worker may actually see more clearly at the close of a day's work under better conditions of illumination than in the morning of a day when illumination is maintained at a low level. It is evident that good lighting has a definite influence upon the conservation of vision. The fact that poor illumination not only affects output immediately, but that adaptation and recovery do not take place until some time after its intensity has been increased, has also appeared in an English experiment in a silk weaving plant. This revealed a marked inferiority of output on days in which artificial illumination had to be used during the first and last hours of the day, as compared with those on which no artificial illumination was used.[65] The ill effects suffered during the first hour of work were serious enough to disturb the production of the workers throughout the entire day.

TABLE 59

The Relationship Between Visual Acuity and Level of Illumination Used at Work-Place

FOOT-CANDLES	DURATION OF PERIOD IN MONTHS	AVERAGE P. M. "ACUITY"	AVERAGE A. M. "ACUITY"
3.3	2	0.530	0.534
2.7	1	0.515	0.516
5.3	1	0.526	0.535
10.7	5	0.530	0.540
5.4	1	0.535	0.544
2.4	2	0.516	0.526
4.0	1	0.493	0.503

(After Ives)

The enormous economic value of increased output obtained by better illumination is evident when it is realized that a 10 per cent increase in production attributable to this factor would be equivalent to:

1,000,000	wage-earners
\$1,000,000,000	in wages
\$2,500,000,000	value added by manufacture
\$6,250,000,000	value manufactured products.[66]

The economic value of adequate illumination appears in a recent study by Goldstern and Putnoky,[67] which is one of a series carried on under the auspices of the Industrial Lighting Laboratory (*Lichtwirt-*

[65] "A Study of Output in Silk Weaving During the Winter Months," *Ind. Fat. Res. Bd., Report* No. 9 (1920), pp. 70.

[66] M. Luckiesh and F. K. Moss, *op. cit.*, p. 227.

[67] N. Goldstern and E. Putnoky, "Erfolgskontrolle arbeitstechnischer Beleuchtungsversuche in einer Juteweberei," *Ind. Psychot.*, 8 (1931), 257–63.

schaftliche Untersuchungstelle) founded by Moede.[68] Production on each of 4 looms in a jute weaving plant, observed between August, 1930, and March, 1931, supplied with 150 watts of properly shaded illumination was found to exceed that of each of 4 looms supplied with 60 watts of badly distributed illumination. An examination of increased production and of increased costs of installing and maintaining the extra lights showed a net surplus of 44.70 R. M. per year for each loom.

In another study,[69] in a wool weaving plant, the effect of lighting conditions upon the efficiency of four weavers was determined by considering three variables:—

(a) Increase in rate of work
(b) Reduction in number of thread breaks
(c) Improved quality of cloth, resulting from a reduction in the number of defects overlooked by the weavers.

Every increase in degrees of illumination (from approximately 150 to 2000 Lux and 100 to 1600 Watts per loom) was accompanied by an improvement in the quantity and quality of production. However, a detailed comparison of increased energy consumption, of the cost of installing and maintaining the improved lighting, etc., with increase in production under different degrees of illumination, and decrease in unit overhead cost, showed that the surplus (i. e. the difference between increased cost and increased revenue) is not proportionate to the degree of illumination. The nature of the relationship is shown in Figure 70.

The maximum economic return is found with an illumination equivalent to 600 Lux or 300 Watts for each loom. Cost actually exceeds revenue where lighting is above the level of 1350 Lux or 1700 Watts. The findings on cost do not refer to improvements in quality. They are not applicable to "weavers" other than those considered in this study. They suggest, however, that there is a point of diminishing economic returns from continued improvement in lighting and that this point may be reached sooner than is implied in the conclusion formulated by Luckiesh and Moss.[70] It is also probable that there is a similar point of diminishing returns in reduced fatigue and in improved individual adjustment, but the conditions under which this is reached are still altogether a matter of surmise.

The benefits of improved illumination are not limited to the economic sphere. Equal in importance to the economic gain, is the increased safety, the increased feeling of comfort, the improved morale, and the improved feeling of well-being, associated with work under satisfactory conditions of illumination. From the consideration of objective data and on theoretical grounds, there seems reason for agreeing

[68] N. Goldstern and E. Putnoky, "Arbeitstechnische Untersuchungen über die Beleuchtung von Webstuhlen," *Ind. Psychot.*, 7 (1930), pp. 321–38.

[69] N. Goldstern and E. Putnoky, "Beleuchtung und Leistung am Webstuhl," *Ind. Psychot.*, 7 (1930), 353–373.

[70] M. Luckiesh and F. K. Moss, *op. cit.*, p. 227.

with Luckiesh and Moss that "good lighting makes human beings better producers with less effort. It has hygienic value. It decreases spoilage. It raises our spirits. It increases safety. It conserves vision. It can do much to maintain and even elevate the standard of living and working as world competition becomes more severe." [71]

The character of the changes necessary to improve illumination de-

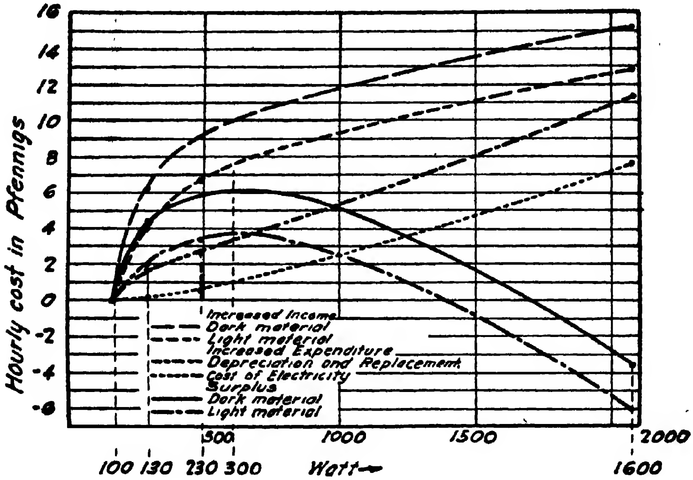


Figure 70. *Comparison of Illumination and Production Costs*
(*After Goldstern and Putnoky*)

pends upon layout of the plant and the character of the work. In general, the most important principles appear to be (1) *that intensity must be adequate for the task,* and (2) *that the visual field must be illuminated as nearly uniformly as possible.*

Increased brightness obtained through increasing intensity of illumination gives greater power for clear seeing through its influence on the retina's power to discriminate detail in the image.[72] The benefit derived from this is particularly great (a) when the work or details to be discriminated are small; (b) for the eye suffering from defects in refraction; and (c) for the old eye. These effects follow from the fact that the retina has less need for high intensities for discriminating detail when the image is large and clear than when it is small and blurred. The latter is apt to be the case in small work or when refraction is defective or the refracting media defective, as in old age.

[71] M. Luckiesh and F. K. Moss, *op. cit.*, p. 231.
[72] C. E. Ferree and G. Rand, *op. cit.*, p. 275 ff.

Evenness of illumination and of surface brightness and proper diffusion of light are important first because of the reflex tendency of the eye to turn toward bright objects in the field of vision [73] so that light reflected by an object may fall upon the "fovea,"—the center of vision. This reflex response as well as the voluntary inhibition of this tendency, to prevent visual attention from wandering from the task, require extra muscular effort and consume energy. A bright object in the field of vision, leading to the reflex response in its direction, also produces a reflex accommodation of the lens, which likewise involves extra muscular movement, conflict, and strain. The contrast of a dark and light surface serves to intensify the brightness of the latter, increasing thereby the amount of glare. Finally bright lights to the side of the eyes tend to throw a glare upon the peripheral portion of the retina, which is ordinarily adjusted to a low intensity of illumination, and produce an extreme feeling of discomfort.

The fundamental principle of vision is that the eye is dominated by a tendency to keep vision clear. Artificial lighting imposes an enormous burden upon the adjustment mechanism of the eye in its attempt to conform to this tendency. This leads rapidly to "fatigue and exhaustion, to deformities slight in their physical magnitude but great in their functional importance" [74] if the burden is not lightened by suitably distributed lighting of adequate intensity.

(b) *The Influence of Colored Illumination*

The effect of colored illumination upon work has been the subject of a number of investigations, only one of which, a study by Ruffer,[75] will be cited in illustration of the methods and findings of such studies. Visual acuity, speed of vision, and manual work involving eye-hand co-ordination were employed in determining the effect of yellow, green, red, and blue in comparison with ordinary day-light. Acuity of vision was measured by means of Snellen Chart material (the various sizes and positions of E) placed on a special background. To measure speed of vision the subject was required to give the position of the opening in a broken circle presented on the tachistoscope. For the measurement of co-ordination, the subject was required to thread pearls, to place 60 pieces of wire 84 mms. in length and .3 mm. in diameter, into holes on a brass plate with a diameter of .75 mm., etc. The subjects of the experiment were 12 office and factory workers in an industrial plant. The variations in degree of illumination included intensities of 5–10–25–50–100–250 Lux. The changes in character of illumination included (a) general illumination, (b) illumination of the work place, and (c) a combination of the two.

[73] A. T. Poffenberger, *op. cit.*, p. 188 ff.
[74] C. E. Ferree and G. Rand, *op. cit.*
[75] W. Ruffer, "Über die Beeinflussung menschlicher Leistungen durch farbiges Licht," *Ind. Psychot.*, 5 (1928), pp. 161–77.

The results show that there is no relationship between the color of general illumination and production. On the other hand, when illumination is confined to the work place, yellow is found to be the most effective color, the remainder ranking in the order of green, red, daylight, blue.

The combination of general and place illumination destroys the relationship between color and production. The absence of relation between the color of general illumination and production appears to be due to the adaptation to color occurring with prolonged exposure to the color. With such exposure the consciousness of color disappears. The question of the extent to which fatigue is associated with work under each of the colors can not be answered from this study. There is not sufficient difference between the performance in the last 20 and the first 20 of 50 trials in the case of any color to warrant the conclusion that eye fatigue tends to occur more in the case of one color than in the case of another. The author points to the existence of individual differences in susceptibility to the effect of colored illumination which require consideration in the selection of workers for jobs in which the task is done in a colored environment.

The findings by Ruffer in the industrial situation agree in general with those of highly detailed laboratory studies by Ferree and Rand. Among the most recent of these is an investigation [76] in which were employed tests of acuity, speed of discrimination, power to sustain clear seeing, and loss of visual efficiency to show the effect of color and composition of light on the visibility of objects. Two intensities of spectrum light were used. Of wave lengths selected at representative points of the spectrum the highest acuity was found for yellow and the lowest for blue. Yellow also stands high on the other tests of visual efficiency. However, as the authors point out, although the eye has developed color reactions it has also developed very elaborate means of getting rid of these reactions for the greater part of its seeing. The complementary character of color reactions, the fact that maximum saturation of color comes at intensities far below those which give an adequate working illumination and the rapid adaptation to the chromatic content of color cause the eye when acted on by colored light rapidly to lose its power to give the color reaction. It appears that the eye was not intended to see and work under what we ordinarily call colored light and color may be considered as a mild physiological drug to be used with intelligence and discrimination and not in large poisonous doses.

(c) *Other Factors in Eye Strain*

There is evidence in English experiments that eye strain and fatigue occurring in fine work can be reduced not only by improved illumina-

[76] C. E. Ferree and G. Rand, "Visibility of Objects as Affected by Color and Composition of Light," *Pers. J.*, 9 (1931), pp. 108–124; 475–492.

tion but also through the use of suitable spectacles. In very fine work, such as mounting lamp filaments or in the linking process in the manufacture of hosiery, the eye must be kept close to the object of work. Under such conditions there is a marked degree of continuous strain imposed upon the muscles of convergence and accommodation. Weston and Adams have shown, in three studies, that the feeling of fatigue can be greatly reduced and output very noticeably increased by providing workers with special glasses designed to overcome the excessive convergence and accommodation made necessary by fine work. The spectacles are such as to provide compensation for the nearness of the object and to permit the work to be done with a degree of accommodation and convergence that is ordinarily present in normal vision.

A preliminary experiment [77] resulted in increased output and other evidence of lessened eye strain in the case of 3 linkers in a hosiery mill. In a later experiment [78] special glasses were provided to 2 girls engaged in sorting minute filaments for telephone switch board indicator lamps and to 3 girls engaged in mounting these filaments. The fineness of the work is indicated by the fact that the diameter of the filaments is only about ½ that of a human hair. Glasses were provided which not only corrected individual errors of refraction but combined in addition prisms to assist convergence and accommodation. Hourly output records were obtained for 6 weeks prior to the use of the glasses and for a 10-week period subsequent to their fitting. The same procedure was followed in the case of 6 experienced operatives engaged in the work of drawing in in a weaving plant, whose output was observed during a control period of 7 weeks and during a period of similar duration after glasses had been provided.

The amount of increase in production in the case of drawing-in varies from 8 to 26 per cent. In the case of the filament sorting and mounting the increase is from less than 1 per cent in an exceptional case to nearly 20 per cent. The evidence suggests that an average increase of output of 12 per cent may be effected through the use of such glasses in cutting down eye strain on fine work. An important by-product from the use of the glasses is the lessened feeling of fatigue on the part of workers employed in these occupations.

The findings of these experiments, although favorable to the use of such glasses, are not clear cut because of the presence of eye defects in a number of the subjects. Inasmuch as these were in every instance corrected, it may be that the increased output, and improved feeling tone follow in part or in whole from the correction in vision, rather than from the use of special prisms to reduce excessive accommoda-

[77] H. C. Weston and S. Adams, "The Effect of Eye Strain on the Output of Linkers in the Hosiery Industry," *Ind. Fat. Res. Bd. Rep.*, No. 40 (1927), pp. 20.

[78] H. C. Weston and S. Adams, "On the Relief of Eye Strain among Persons Performing Very Fine Work," *Ind. Fat. Res. Bd. Rep.*, No. 49 (1927), pp. 30.

tion and convergence. In a more recent experiment [79] 13 subjects, engaged in examining steel balls, cloth mending, and in linking hosiery, were supplied with special spectacles which reduced the amount of accommodation and convergence necessary to that which would be used if the eyes were kept at a distance of about 15″ from the work, that is, approximately at comfortable reading distance for individuals with normal vision. The average improvement in production of workers with *normal* and *abnormal* vision is shown in Table 60.

TABLE 60

Average Improvement in Production

TYPE OF WORK	PERCENTAGE IMPROVEMENT IN WORK WITH NORMAL VISION	PERCENTAGE IMPROVEMENT IN WORK WITH ABNORMAL VISION
Ball Examining	26.7	28.4
Cloth Mending	21.9	12.3
Linking Hosiery	2.1	5.9

(After Weston and Adams)

It is evident from these figures that the improvement in output can be directly attributed to the use of special spectacles for reducing eye strain in excessive accommodation and convergence. Workers included in this experiment experienced the same satisfaction with the glasses as those who were the subjects of earlier investigations in this field.

4. THE EFFECT OF ATMOSPHERIC CONDITIONS

Atmospheric conditions play a part in determining the efficiency and well-being of the worker. "The industrial worker spends the major part of his active life in an environment where heat, moisture, and in some special cases, injurious elements are constantly evolved by the process of manufacture." [80] These conditions, as a result of their effect on the health and comfort of the workers, grossly affect the quantity and quality of output and the general efficiency of the worker and of the plant.

Until comparatively recent years the effect of bad air upon human efficiency was thought to be largely due to the increase of carbon dioxide in the air. Recent experimental work does not support this theory. In pure air the proportion of oxygen is 21 per cent, of nitrogen

[79] H. C. Weston and S. Adams, "Further Experiments on the Use of Special Spectacles in Very Fine Processes," *Ind. Fat. Res. Bd. Rep.*, No. 57 (1930).

[80] C. P. Yagloglou, "Modern Ventilation Principles and Their Application to Sedentary and Industrial Life," *J. Pers. Res.* (1925), p. 389.

78 per cent, of carbon dioxide 0.03 per cent. In the most poorly ventilated schools and factories which have been experimentally observed the percentage of oxygen is seldom reduced below 19 per cent and the percentage of carbon dioxide almost never increased above 0.3 per cent. To produce adverse physiological effects, oxygen must be reduced to 14 per cent and carbon dioxide increased to 0.4 per cent.[81]

The secondary importance of oxygen and carbon dioxide content of the air in producing adverse effects has been demonstrated in a series of experiments conducted by the New York State Ventilation Commission,[82] in which individuals kept in air tight chambers showed the usual symptoms of poor ventilation even when permitted to breathe fresh air by means of tubes from the outside of the room.

The findings of laboratory and plant studies have shown that the depressing influence of poor ventilation is associated with the *temperature* and *humidity* of the air and with *air movement*. The interoperation of these factors in affecting efficiency and subjective feelings is illustrated in the experience of Europeans in tropical countries.[83] It is a common finding in such countries that work can be done more efficiently and more comfortably in dry air at a high temperature, than in moist air at a lower temperature. In addition, work can be comfortably done in moist air provided that its movement is maintained by use of fans which serve to increase the rate of evaporation of moisture from the body. Somewhat similar conditions exist in the industrial plant, because here, as elsewhere, the well-being and efficiency of the worker is determined by the extent to which *radiation*, *convection* and *evaporation* of excess body heat and moisture is facilitated.[84] The body discharges heat to the air and warms surrounding objects by radiation in exactly the same manner as the sun warms the earth. The air heated through contact with the surface of the body rises, while cooler air takes its place, thus setting up convectional currents which help carry away the heat developed by the body. In addition, the air evaporates moisture from the surface of the body.

The amount of heat carried off by radiation and convection depends upon the temperature of the air and the amount of its motion, while the evaporative cooling effect depends upon the capacity of air for absorbing moisture and upon its movement. Heat loss, both by convection and evaporation, is greatly accelerated in the presence of wind, which carries away the warm and saturated film of air in contact with the body and replaces it with cooler and drier air.[85]

[81] A. T. Poffenberger, *op. cit.*, p. 166.

[82] "Ventilation," *Report of the New York State Commission on Ventilation*, New York, (1923).

[83] *Eleventh Annual Report of the Industrial Health Research Board*, London, (1931), p. 6.

[84] "Air Conditions and the Comfort of Workers," *Ind. Health Ser. No. 5*, New York, (1932), pp. 11–12.

[85] C. P. Yagloglou, *op. cit.*, p. 379.

The temperature of the atmosphere, known as *dry-bulb temperature*, is obtained by means of an ordinary mercury thermometer. The amount of moisture, known as *wet bulb temperature*, is obtained by covering the bulb of the thermometer with a piece of wet gauze and fanning or whirling the thermometer so as to produce evaporation of the moisture. Simultaneous dry bulb and wet bulb may be obtained by an instrument known as the *sling-psychrometer*. Air motion is measured by the *Kata-thermometer*, designed by Sir Leonard Hill,[86] which constitutes, especially at low velocities, a useful instrument in readily detecting drafts or air infiltration through windows. "Fundamentally, this is a specially constructed alcohol thermometer with a cylindrical bulb about four centimeters in length and two centimeters in diameter.[87]—In taking a reading, the kata is immersed in hot water until the alcohol rises to a top reservoir. The bulb is then dried and the instrument is suspended in the selected location. The time taken for the fluid to fall from 100 degrees to 95 degrees, measured by a stop watch, is a criterion of the heat loss from the surface of the kata by radiation and convection. Since the heat loss from the surface of the kata in dropping from 100 degrees to 95 degrees is a known factor (and is written in the back of the thermometer in millicalories per square centimeter of kata surface and is known as the 'kata factor'), the *rate* of the loss depends entirely upon the atmospheric environment. It is obvious, therefore, that there exists a definite relation between the time of cooling of the kata-thermometer and the atmospheric conditions. The rate of heat loss is determined by dividing the kata factor by the time of cooling, in seconds, from 100 degrees to 95 degrees F. After determining the rate of heat loss and ascertaining the dry-bulb temperature by an ordinary thermometer, the air motion is easily calculated by means of a formula or table." [88]

The extent of influence of atmospheric conditions upon fatigue and production is illustrated in an investigation by Wyatt, Fraser, and Stock,[89] designed to determine the influence of the amelioration of temperatures and humidity in a weaving shed, through the use of suitably placed fans. Fans were run on alternate working days over a period of 6 weeks during the summer. Following this they ran continuously for a week and were then stopped for a similar period. The rate of air movement and the cooling effect produced by fans was measured by means of kata-thermometer readings taken at alternate ½ hours through each day. Wet and dry bulb thermometer readings were taken at the same time. The findings indicated that output on

[86] Leonard Hill, *The Science of Ventilation and Open Air Treatment*, Part I, London, (1919).

[87] *Industrial Health Series No. 5*, New York, (1932), pp. 12 ff.

[88] *Ibid.* Cited from "Report of Committee on Standard Methods for Examination of Air, Amer. Pub. Health Assoc.," *American Journal of Public Health*, Vol. 7, No. 1, Jan., 1917.

[89] S. Wyatt, F. A. Fraser and F. G. L. Stock, "Fan Ventilation in a Humid Weaving Shed," *Ind. Fat. Res. Bd. Rep.* No. 37, London (1926), pp. 33.

looms affected by fans was higher on days when the fans were running than on other days, the increase being particularly noticeable at periods when temperature and humidity were unusually high. The influence of fans upon output is shown in Figure 71. In addition to increasing output, reports by workers showed that bodily comfort was considerably increased by the operation of the fans.

The influence of atmospheric conditions has been illustrated in a

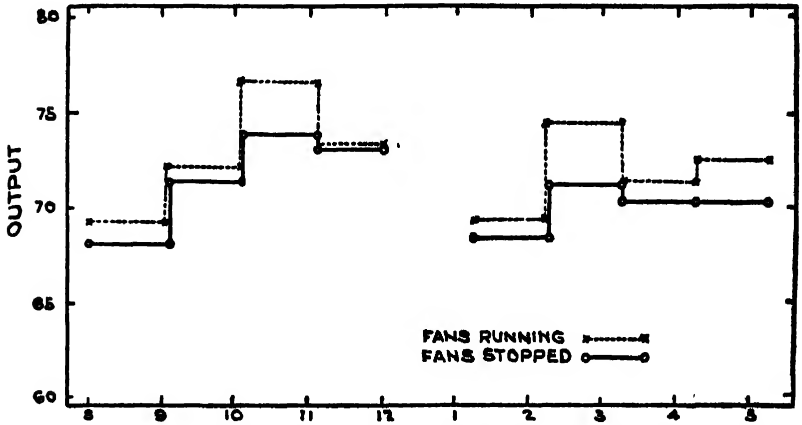


FIGURE 71. *Hourly Variations in Output During a Composite Day with (a) Fans Running, (b) Fans Stopped*

(After Wyatt, Fraser and Stock)

number of studies in the mining industry. In metal mines in a still atmosphere of 80 to 90° F., it was found that manual labor caused the body temperature to rise to 102° and frequently to 103° when humidity exceeded 95 per cent.[90] Physiological and psychological changes under these conditions included a rapidly increasing pulse, a marked loss of weight accompanied by physical weakness, exhaustion, and difficulty in carrying on mental work. When the air movement was stirred up to a velocity of between 400 and 500 feet per minute, the physical changes and the feelings of discomfort disappeared. It is evident in this, as in other studies, that the "cooling power" of the moving air is the most important factor in determining the comfort and efficiency of the workers.

Vernon, Bedford and Warner [91] have taken advantage of the varia-

[90] R. R. Sayers and D. Harrington, "Physiological Effects of High Temperature and Humidity with and without Air Motion," U. S. Bureau of Mines, *Report of Investigation,* Serial No. 2464.

[91] H. M. Vernon, T. Bedford and C. G. Warner, "The Relation of Atmospheric Conditions to the Working Capacity and Accident Rate of Miners," *Ind. Fat. Res. Bd. Rep.,* No. 39 (1927), pp. 34.

tions in atmospheric conditions in coal mines to determine their influence upon the efficiency of miners. In certain mines, where temperature is approximately 60° F. at the surface and increases about 13° for every thousand feet in depth, the temperature may exceed 100° F. There are also marked variations in the humidity or moisture content of the air. Since the facility with which coal is mined differs greatly in different mines, the investigators depended upon duration of voluntary rest pauses and the time taken to fill tubs in measuring the efficiency of workers. In the case of 138 men, observed for an average period of 96 minutes each, the investigators found that miners working under the more satisfactory atmospheric conditions rested for 7 minutes per hour, while those working at the higher temperatures rested on the average of 22.4 minutes for each hour. In addition, the latter took 9.6 minutes to fill a half-ton tub of coal in comparison to 8 minutes taken by those working at lower temperatures. The average working capacity of those working under the less favorable conditions was 41 per cent less than of miners working under the better atmospheric conditions.

A later unpublished study [92] of 340 men, observed for an average period of 97 minutes each, showed that the time taken for rest is more closely associated with the dry bulb factor than with the wet. The investigators in this later study, Bedford and Warner, point to the desirability of a much more complete analysis of the various factors with a more satisfactory criterion than that of duration of rest pauses. However, the results suggest that in a hot dry mine working conditions and efficiency might be improved by the use of artificial humidification.

In another investigation [93] 500 sets of observations on temperature and air velocities in various pits showed that time lost from sickness was greatly influenced by temperature. Miners working in higher temperatures experiencing 65 per cent more sickness than those working at lower temperatures. This is evident in Table 61. While velocity also appeared to play a part in determining sickness, the exact influence

TABLE 61

Influence of Temperature upon Sickness

RANGE OF DRY BULB TEMPERATURE	PERCENT OF TIME LOST FROM SICKNESS	RANGE OF WET BULB TEMPERATURE	PERCENT OF TIME LOST FROM SICKNESS
Under 70 degrees	3.0	Under 66 degrees	3.0
70 to 79.9 degrees	4.5	66 to 69.9 degrees	4.2
80 or more degrees	4.9	70 or more degrees	5.0

(After Vernon, Bedford and Warner)

[92] *Eleventh Annual Report,* Industrial Health Research Board, London, (1931), p. 59.
[93] H. M. Vernon, T. Bedford and C. G. Warner, "A Study of Absenteeism in a Group of Ten Collieries," *Ind. Fat. Res. Bd. Rep.*, No. 51 (1928), pp. 58.

of this factor could not be determined because of differences in other variables, particularly age, in the case of the men investigated in this study.

The Research Laboratory of the American Society of Heating and Ventilating Engineers has made use of psychrometric rooms, provided with the most modern air conditioning equipment, to determine the effect of variations in temperature, humidity and air movement. A series of experiments, involving in all 130 subjects, showed that "the optimum temperature for individuals at rest, or otherwise engaged in light activity in still air and normally clothed" to be 64.5 effective temperature.[94] It is recognized that the optimum temperature for a particular industry depends upon the nature of the work performed. More body heat is produced in connection with heavy muscular work than in connection with light muscular work and it is, therefore, necessary to increase greatly the cooling power of the air in order to effect a greater heat loss from the human body. The conditions of work in a steel or tin rolling mill require an entirely different treatment of the air to promote the comfort and production of the worker than does work in a laundry, in the assembly room of a radio manufacturing plant, or in other forms of light labor. Considerable experimental work remains to be done to determine the optimum effective temperature for individuals doing various amounts and kinds of work. The experiments conducted by the Research Laboratory of the American Society of Heating and Ventilating Engineers, by the Industrial Health Research Board and by other organizations, are making possible a standardization of these conditions for many different representative industries.

5. ELIMINATING UNNECESSARY FATIGUE THROUGH ECONOMY OF EFFORT

Inefficient working methods and badly designed machines and tools are responsible for a tremendous waste of human effort, increased dissatisfaction in work, and reduced output. The demonstration that output can be increased and fatigue reduced by the elimination of useless movement through changes in methods of work and in machine and tool design, and by the rearrangement of materials and tools, represents perhaps the most important contribution of scientific management. Taylor's classic experiment in loading pig iron,[95] Thompson's

[94] C. P. Yaglogiou, *op. cit.*, p. 388. Effective temperature is a temperature obtained by considering the combination of dry and wet bulb temperatures. A psychrometric chart developed by the American Society of Heating and Ventilating Engineers' Research Laboratory makes it possible to determine the effective temperature and the warmth and comfort of any combination of dry and wet bulb temperatures in still air. Additional tables make it possible to determine the amount of air velocity necessary to overcome increase in temperature and humidity in maintaining a standard condition of body warmth and comfort.

[95] See pages 10–13.

investigation of ball bearing inspection,[96] Gilbreth's analysis of brick laying,[97] are the first of a long series of investigations which have veritably revolutionized both working methods and machine design in many industries. The significance of improved techniques has been further increased by supplementing the objective of increased output,—of improved *economic efficiency*—with an emphasis upon human welfare—*individual fitness*—as a necessary criterion in judging the effectiveness of these techniques. The narrow selfishness of earlier years has been supplanted by a broader social self-interest which accords to physiological and psychological values a place left vacant in a system that was neither good science nor good management in its neglect of a variable—the human factor—which, in spite of the grandeur of its machine setting, plays the most important rôle on the stage of industry.

The *elimination of useless movements* represents one of the distinctive approaches in promoting economy of effort. The elimination of such movements involves a complete study of methods of work and the determination of the *best way,* or *best ways,* of working. Procedures for accomplishing this have already been described in the chapters on training (See Chapter XX), in which reference has also been made to their significance from the viewpoint of fatigue reduction.[98]

Perhaps equal in importance to the way work is done is the *posture* adopted in work, the *load carried,* and the *distribution of load* when carrying or lifting are involved. The influence of posture is shown, for example, in the fact that 30 calories [99] per hour are required for dish

[96] See page 13.

[97] See pages 13–15.

[98] The literature on the analysis of skilled movements as they affect economy of effort has recently been reviewed in the following article, which also contains a lengthy bibliography on experimental work in this field. L. D. Hartson, "Analysis of Skilled Movements," *Pers. J.*, 11 (1932), pp. 28–43.

[99] The output of energy in work is often expressed in terms of units of heat or *calories* expended in the course of work. "The output of energy by a subject may be determined in two ways; either by direct or indirect *calorimetry*. The common unit of measurement utilised for all assessments, that is, for the expenditure both at rest and during work, is the large or kilo calorie.

In direct calorimetry, the subject is enclosed in a special chamber which is so arranged that all the *heat* given off by the subject can be measured directly as heat. As a rule, combined with the special apparatus for the determination of heat, all the air passing into and coming from the chamber can be measured and analysed, that is, direct and indirect calorimetry are combined. The objection to such calorimeter methods for the examination of a subject performing ordinary work, is that the chamber is apt to limit his movements and the conditions are always artificial.

In indirect calorimetry, the energy output is computed from *chemical* measurements of the respiratory exchange. By the Douglas-Haldane method, when a determination is being carried out, the subject wears a mouth-piece or a face-mask equipped with two one-way light rubber valves. One of these valves communicates directly with the outside air and serves for inspiration; the other valve, which is connected by means of a length of rubber tubing to a large gas-tight bag carried on the back of the subject, serves for expiration. The expired air of the period, usually two to three minutes during a work experiment, is then carefully measured and a sample is drawn off into a gas sampling tube for analysis. The gas is analysed in a Haldane apparatus and the amount of oxygen (O_2) used, and the amount of carbon dioxide (CO_2) given off in the period of experiment, are determined. The

washing on a table 65 cms. in height; 24.4 calories with a table 100 cms. in height and 20.3 with a table 85 cms. in height.[100]

Illustrative of studies on the energy cost of various postures and distribution of loads is an investigation of Bedale,[101] who used pulse rate, blood pressure, oxygen consumption and caloric expenditure to measure the amount of energy expended when weights varying from 20 to 60 pounds were carried in each of 8 positions suitable for carrying loads. One trained laboratory subject was required to carry loads varying in weight from 20 to 60 pounds over a route 100 yards in length at a pace of about 2.8 miles per hour for a period of 2 hours every morning. In order to represent ordinary working conditions the load was not carried continuously, but each circuit with loaded tray or other carrier was alternated with another complete circuit in which the subject carried only an "empty." The 8 modes of carriage employed in the course of the investigation were as follows:

1. *Tray carried in front of the body.*
2. *Tray carried in front but with the weight taken off the arms by a strap around the shoulders and fastened to the corners of the tray.*
3. *Weight tied in equal bundles and carried at the sides of the body in either hand.*
4. *Weight distributed over a board carried on left shoulder.*
5. *Weight carried in tray on left hip.*
6. *Weight carried in a rucksack.*
7. *Weight divided equally between two pails and carried on a shoulder yoke.*
8. *Weight carried in a tray upon the head.*

The results show that carrying the load on a yoke represents the most efficient method from the viewpoint of physiological cost to the worker. Hip carrying is metabolically the most costly method of transporting material for every weight. This apparently is most disadvantageous with respect to all four factors influencing carrying, viz., *local strain, posture, gait,* and *chest freedom.* The figures show that regardless of the way in which the load is carried the cost of work per horizontal *kilogrammeter* rises with the load carried, although no attempt was made in this experiment to determine the weight of the most suitable load.

The findings of Bedale on the cost of carrying loads have been confirmed in a later study, involving an additional subject, by Cathcart

ratio of CO_2 excreted to O_2 absorbed is then obtained. The volume of oxygen utilized in a given period, say one minute, is converted into an assessment in heat units by multiplication with a factor determined experimentally and based on the CO_2–O_2 ratio." (E. M. Bedale, "Comparison of the Energy Expenditure of Woman Carrying Loads in Eight Different Positions," *op. cit.*, p. 2.) See Plates VI and VII.

[100] W. L. Wheeler, "Measuring the Energy Cost of Work," *Ind. Psychology,* 1 (1926), p. 629.

[101] E. M. Bedale, "Comparison of the Energy Expenditure of a Woman Carrying Loads in Eight Different Positions," *Ind. Fat. Res. Bd. Rep.,* No. 29 (1924), pp. 1–27.

and others.[102] In this study it is again found that any posture which brings about a considerable departure from the erect posture, which induces local strain, etc., leads to a high physiological cost. A study of optimum load leads the investigators to conclude that a load of 40 per cent of the body weight should not be exceeded by women engaged in continuous work, whereas for occasional loads the figure of 50 per cent of body weight is a permissible maximum. For the average adult woman a load of about 45 pounds would appear to be optimal for continuous carriage, although the body of the average weight worker would not be strained if the maximum were placed at 50 pounds. The investigators recommend that in the case of young women from 16 to 18 years of age a load of 40 pounds should not be exceeded; for girls from 14 to 16 years of age, a load of 35 pounds should be the maximum. An interesting by-product of this study is the finding that where the worker is free to choose her own load, the actual weight selected generally conforms to the physical capacity of the worker.

An investigation on the physiological cost of different methods of work and different loads in hauling bricks on a wheelbarrow is reported by Crowden.[103] Physiological cost was measured by oxygen consumption during work (Plate VI). Air expired in the course of 30 minutes of work (collected in a Douglas-Haldane bag) was compared with a 10-minute collection of expired air obtained after a rest period of 30 minutes immediately preceding work and with a 10-minute collection obtained during rest immediately subsequent to work. The experiment included measurement of air consumption in wheeling a barrow at a *slow walk*, a *normal brisk walk*, at a *very quick walk*, and a *gentle run*. The results obtained, shown in Table 62, indicate that, from the viewpoint of physiological cost, the optimum rate for wheeling a barrow is at a normal brisk walking pace. An analysis of the load, of the methods of loading the barrow and of the tension exerted upon the arm by various handle heights showed that these affected physiological cost of work and led to the adoption of optimum load and of an arrangement of load which entails a minimum expenditure of energy and permits the greatest comfort to the worker. These necessarily involved changes in the design of the wheelbarrow. An interesting observation of the investigation is that the normal cycle of work (1) loading the barrow, (2) pushing the barrow, (3) unloading the barrow, (4) returning with the empty barrow, provides the worker with almost all the advantages obtained by rest pauses under other conditions of work.

The elimination of fatigue involves not only a complete study of methods of work, posture, etc., but a very careful analysis of *machine design* in order to eliminate the unnecessary or uncomfortable move-

[102] E. P. Cathcart and others, "The Physique of Women in Industry," *Ind. Fat. Res. Bd. Rep.*, No. 44 (1927), pp. 140.

[103] G. P. Crowden, "The Physiological Cost of the Muscular Movements Involved in Barrow Work," *Ind. Fat. Res. Bd. Rep.*, No. 50 (1928), p. 22.

ments resulting from a failure to consider the human element in building the machine. Until recently the dominant emphasis in machine construction has been on the adaptation of man to machine, rather than upon the adjustment of the machine to the human limitations in the way of posture, reach, speed, rhythm, etc. This unilateral viewpoint has proven to be inadequate because of the waste of human effort, the decrease in production and the feeling of dissatisfaction engendered by a neglect of the reciprocal relation between the individual and the machine he operates.[104]

The neglect of this relationship is evident, for example, in the construction of one of the most frequently used machines—the typewriter. An analysis, by Hoke,[105] of the distribution of movements in typewriting showed that of 37,356 movements only 16,055 were struck by the right, or more efficient hand, and 21,301 by the less efficient left hand. When the efficiency of individual fingers and the frequency of appearance of various letters of the alphabet are taken into account, it appears that the percentage of ideal load for the first finger of the right hand is 135.8, for the second, 58.4, for the third, 100.5, for the

TABLE 62

Physiological Cost of Wheeling Barrow at Various Rates

	SLOW WALK	NORMAL BRISK WALK	VERY QUICK WALK	GENTLE RUN
Excess O_2	2,520 cc.	2,480 cc.	4,040 cc.	3,660 cc.
Relative values	1.01	1	1.63	1.47
Excess O_2	2,515 cc.	2,280 cc.	4,405 cc.	3,887 cc.
Relative values	1.1	1	1.77	1.7
Excess O_2	1,560 cc.	1,240 cc.	2,040 cc.	1,960 cc.
Relative values	1.26	1	1.64	1.58
Mean relative values	1.12	1	1.68	1.58

(After Crowden)

fourth, 30.6. In other words, the first finger of the right hand is overloaded and the second finger under-loaded. With a percent of ideal load of 153.0, the second finger of the left hand is also shown extremely over-loaded. Hoke recommends a rearrangement of the typewriter keyboard, as shown in Fig. 72, to make possible a more effective use of energy in typing.

Studies of typewriter construction by Lahy, extending over a period

[104] A. Gemelli and A. Galli, "Sur L'Adaptation de l'Activité Humaine à l'Activité de la Machine," *Rev. de la Sci. du Trav.,* 2 (1930), p. 324.

[105] R. E. Hoke, *The Improvement of Speed and Accuracy in Typewriting,* Baltimore, 1922, pp. 118.

of 20 years,[106] have also shown the need of major changes in this machine to provide a satisfactory balance between psycho-physiological trends in human response and machine operation. The so-called universal keyboard, according to Lahy,[107] by grouping most frequently used letters in regions where they can presumably be most easily

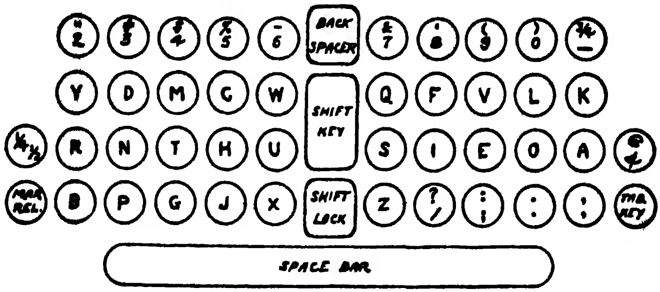


FIGURE 72. *Suggested Rearrangement of Typewriter Keyboard (After Hoke)*

reached, neglects the influence of combination of letters on rapidity of stroke. An analysis of the duration of intervals separating successive letters has shown that the interval is significantly shorter when alternate hands, instead of the same hand, are used. The desirability of rearranging type to provide the most frequent alternation of hands in combinations of strokes are suggested by this finding. In his most recent work, in association with Estoup, by photographically recording rapid movements on the typewriter Lahy [108] has found that the reaction time for automatized voluntary movements, as determined by intervals between strokes on the typewriter, ranges around 0.03 sec. An analysis of construction features influencing the "touch" of the machine—the feeling of "lightness" and "heaviness" experienced in its operation—and of the "dove-tailing" of successive strokes furnishes further evidence on the importance of collaboration between engineer and psychologist in machine construction as an aid in promoting human efficiency.

Characteristic defects in machine design are described by Legros and Weston,[109] who have investigated the construction of laundry machines, leather working machines, boring mills, and other factory

[106] J. M. Lahy, "Les Signes Physiques de la Superiorite Professionnelle chez les Dactylographes," *R. R. Acad. D. Sci.*, Paris, 1913.

[107] J. M. Lahy, "French Psychologists Improve Typewriting," *Ind. Psych.*, 1 (1926), pp. 333–337.

[108] J. M. Lahy and H. Estoup, "Étude Graphique de la Frappe Dactylographe," *Rev. de la Sci. du Trav.*, 2 (1930), pp. 171–85.

[109] L. L. Legros and H. C. Weston, "On the Design of Machine in Relation to the Operator," *Ind. Fat. Res. Bd. Rep.*, No. 36 (1926), pp. 34.

equipment. Ironing machines, for example, were found to have a pedal movement requiring the worker to support her weight on one foot during a large part of the working day. In the operation of a leather working machine the weight is supported on one foot and the machine controlled with the heel of the other. In the case of the vertical boring machine, controls are located on the outer sides, requiring the worker either to reach over, at the expense of much local strain, or to move from his position between the two tables to operate them. In this study the difficulties in gathering data on the mechanical energy used in performing the machine tasks were such that the investigators were able only to arrive at a classification of the factors in machine and design construction that may tend to produce unnecessary fatigue without offering exact data on the effects of each in the case of the plants which were studied. The principal factors are classified by these investigators as:

1. *Movement* (extent, kind, speed, rhythm, and combinations of these).
2. *Posture* (height, position of work).
3. *Effort* (includes all machines in which the operative supplies the motive power and also operates the controls; also some in which the operation of the control is laborious, such as steering heavy vehicles).
4. *Danger* (machines, the working of which is attended by risk of being cut, crushed, or drawn in).
5. *Shock* (arrested movement or cessation of resistance).
6. *Vibration* (of the whole machine or of the part held or part operated).
7. *Noise* (produced by the machine or the material on which it operates).
8. *Obstruction* (of part of machine to the operative or his vision).
9. *Motion* (parts of machine moving through a large angle of vision).
10. *Adjustment* (affected by uncontrollable causes involving uncomfortable posture and avoidable work).

Fatigue is increased not only by unsatisfactory machine design but also by an unsatisfactory *arrangement of material.* As in the case of the machine, this involves unnecessary movements, excessive reaching, and other activities which may grossly affect the output, the physiological cost of work, and the comfort of the worker.

On many jobs the worker must reach for tools and materials hundreds, often thousands, of times a day.[110] A rearrangement of the material, an alteration in the height of a bench, a small decrease in the distance of a bin, may save an enormous amount of muscle strain, body movement and discomfort, as well as increase production. Inter-

[110] G. H. Miles and A. B. Eyre, "Ease and Speed of Work," *Industrial Psychology* (edited by C. S. Myers), London (1929), p. 94.

ruptions of rhythmic action serve to disturb efficiency and to increase the cost of work. The feelings of annoyance and irritation contribute further to disturb maladjustment growing out of the neglect of this apparently obvious but often disregarded variable.

6. THE INFLUENCE OF SPEED AND RHYTHM OF WORK

Speed and rhythm of work imposed by the machine, by the moving belt, and by other conditions of work grossly affect the efficiency of the worker. The findings of laboratory and plant studies have shown that the automatic machine and the moving belt almost universally tend to increase the rate of production. Although the situation, in most instances, is confused by the introduction of new standards and new wage scales simultaneously with the introduction of a new automatic machine or a change-over to a moving belt, there is reason to believe that increased production is partly due to the regular and rhythmic character of work under these conditions as compared with the progress of output when the tempo is under the control of worker. The influence of rhythm, isolated from other variables, is well illustrated in an investigation by Reinhardt [111] in which 8 boys, 14 years of age, were required to sort 204 metal plates, each 30 mms. square. Among these were 90, divided into 6 groups of 15 numbered from 1 to 6 respectively. Each of the numbered plates was sorted into a separate compartment, the remaining plates being placed into another receptacle. The work was carried on for 2 hours. The subjects were divided into 2 groups, one working in rhythm with a metronome and the other at a free tempo. Eight months after the original investigation the experiment was repeated, the groups being reversed. It was found that rhythm increased production by 17.8 per cent. The rhythmic work was also accompanied by less fluctuation in the rate of work and by a marked increase in the interest and satisfaction of the subjects, who, in general, expressed themselves as feeling less tired when working with an imposed rhythm. Individual differences in this respect are, however, noted by the author.[112]

Similar experiments with students and apprentices as subjects, working on simple, heavy tasks and complex, light tasks give approximately the same results. In the case of complicated, heavy work, the use of the metronome fails to lead to an improvement of output because the numerous elements in this task (21) interfered with the establishment of a fixed rhythm.

The influence of rhythm has also been investigated in a laboratory study by Düker [113] designed to determine (a) whether work on the

[111] H. Reinhardt, "Rhythmus and Arbeitsleistung," *Ind. Psychot.*, 3 (1926), pp. 225–237.
[112] See pages 435–37.
[113] H. Düker, "Psychologische Untersuchungen über die Arbeit am laufenden Band," *Ind. Psychot.*, 6 (1929), pp. 214–24.

moving belt, characterized by rhythm, increases production; (b) the effect of such work on the feeling of fatigue; and (c) the reasons for such differences between work on the moving belt and under other conditions entering into the experiment. As an intellectual task the experimenter employed a series of continuous additions similar to those used in Kraepelin's original investigations on the work curve. For manual work the subject was required to run a needle through a series of dots placed on a moving roll of paper. In one phase of each task the subject controlled the rate of presentation of each unit of work; in the second phase the work was done at an imposed regular rate. The investigation involved 15 minutes of work each day for a period of 8 days.

Output was significantly greater and errors significantly less when the tempo of work was imposed from without than when the worker set his own pace. In addition, introspective reports by the subjects clearly indicated that they experienced less fatigue and felt more satisfied with the work under the first conditions. An analysis of the introspective reports leads Düker to conclude that work on the moving belt, at an imposed tempo, is advantageous because it relieves the worker of the need of exercising volitional effort in carrying on the work. On the moving belt energy is expended only on the work itself, whereas, when work is done at a free tempo, to the energy expended on the operations of the job must be added that involved in its volitional direction. In the absence of rhythm, as Myers [114] has also pointed out, conscious efforts have to be invoked to carry on the work which, in addition, is not characterized by the smooth flow of coordinated movement typical of rhythmic work.[115]

Further investigations of this type, in the industrial situation, supplemented by exact measurement of the physiological cost of work, are needed. Although there is universal agreement that the machine and the moving belt, partly by reason of an enforced rhythm, speed up production, there appears to be reason for questioning the effect of such increased speed upon the ultimate effectiveness or physical and mental fitness of the worker. Hill has shown, for example, that approximately four times as many calories are expended (115) in walking a mile at 5 miles per hour than in walking this distance at the rate of 2 miles per hour (30).[116] A very quick walk in wheeling a barrow involves 1.68 the amount of energy consumption as in wheeling it at a normal, brisk walk (Table 62). On the other hand, very slow movement, as in climbing a mountain, is a waste of time and does not prevent one from becoming fatigued.[117]

[114] C. S. Myers, *Industrial Psychology in Great Britain*, London, 1926, p. 55.

[115] The effect of rhythm on fatigue in repetitive work is closely associated with the incidence of monotony and individual differences in susceptibility to monotony on repetitive tasks. These problems are discussed in Chapter XXIV.

[116] A. V. Hill, *Living Machinery*, New York, (1928), p. 158.

[117] *Ibid.*, p. 195.

The efficiency of working on practically every task, i. e., the ratio of the work done to the energy expended in doing it, rises up to a certain speed and falls off again.[118] For every type of work there exists an optimal speed, which will make it possible to get as much as is possible done with the least expenditure of energy and without increasing the feeling of fatigue, discomfort, and ill health.[119] The determination of these speeds, from the viewpoint of human efficiency, is an almost untouched field. They have been fixed again and again, for many types of work, with respect to highest rate or amount of production, but there is reason for believing that this rate often conflicts with the optimum welfare of the worker. The effect of variations of speed upon fitness remains a fertile field of investigation by the industrial psychologist.

7. THE EFFECT OF NOISE

Casual observation in the industrial plant and in other surroundings has suggested that excessive noise may adversely affect output and fatigue. One of the earliest studies of the effect of noise upon production and upon energy output necessary for production is a laboratory study by Morgan,[120] in which the subjects were required to translate letters into numbers and numbers into letters by means of a code, the difficulty of which varied in different parts of the experiment. Translations were recorded on a typewriter. Production was measured quantitatively in terms of number of units translated, and qualitatively in terms of accuracy. Energy expenditure was measured by noting changes in character of breathing, the rate of breathing, and the amount of pressure exerted upon the keys used in recording the translation.

The noises included a variety of buzzers, electric bells, and a series of 6 phonograph records. In the progress of the experiment *quiet* periods were alternated with *noisy* periods. In the case of every subject the introduction of the noise served at first to slow the time taken for translating the code. However, the decrease in rate of output was quickly followed by a rapid rise in speed of work. In the case of 6 of the 8 subjects, better records were obtained during the noisy period than during the quiet period. In so far as quantity and quality of production are concerned, noise not only failed to slow up work but seemed to have a "dynamogenic effect" in spurring the subject to increased activity. However, the records of key pressure showed that greater effort was exerted through the noisy periods than in the quiet periods and that expenditure of energy was at its maximum at the beginning of the noisy period. A rising breathing curve gave further indication of the effort required for adjustment to the new situation, par-

[118] *Ibid.*, p. 203.
[119] *Ibid.*, p. 204.
[120] J. J. B. Morgan, "The Overcoming of Distraction and Other Resistances," *Arch. of Psych.*, 35 (1916), pp. 84.

ticularly at the beginning of the noisy period. However, as a result of strain and "articulation" of breathing, the adverse effect of noise upon production was overcome, and these, associated with the enforced attention to the task, led to an increased production in the noisy as compared with the quiet period.

The cost to the organism of work under noisy conditions is illustrated in a laboratory experiment by Laird [121] at Colgate University. Four typists, 2 men and 2 women, spent 2 hours a day for 4 weeks copying the same letter again and again. Work was done in a special cubicle test chamber 10 feet in each dimension, lined with Acousti-cellotex building board and panels. (See Plate VII.) Noise was produced by mechanical means. During the first and last week of the experiment "quiet" conditions were maintained by the use of the Acousti-cellotex panels, whereas during the middle 2 weeks "noisy" conditions were maintained by removing these panels.[122]

After a uniform breakfast the 4 typists were "weighed-in," entered the test chamber and had their masks attached at 8 A. M. For one-half an hour each sat in front of a "noiseless" typewriter in the position assumed when typing but without actually typing. A sample of exhaled air was collected, by means of a Douglas bag, at 8:30 A. M. and analyzed to determine the amount of energy expended while resting. At 8:30 A. M. the noise machine was started (with or without the sound absorbing panels) and the typists were instructed to work at top speed. Every 15 minutes during the 2-hour work period a sample of exhaled air was collected and analyzed to determine the callories expended per minute of work. An analysis of exhaled air showed that during the noisy phase the average expenditure of energy was 71 per cent higher during typing than in the resting period; while in the quiet phase the average increase was only 51 per cent. Introspective observations also indicated the existence of a curve of annoyance during noisy conditions of work.

The working hypothesis of this investigation is that noise does not affect the nerve cells of the ear but serves as a natural stimulus to the fear reaction. This according to the investigator leads to an excessive dissipation of energy, through increased muscle tonus, even though there is no consciousness of fright. The fact that difference in energy output appears as early as 10 minutes after typing had begun is cited by the investigator in support of this "fear-reaction hypothesis" on the assumption that fatigue would not appear so early.

Additional experiments, including the examination of the effects

[121] D. A. Laird, "Experiments on the Physiological Cost of Noise," *J. Nat. Inst. Ind. Psych.*, 4 (1929), pp. 251–58.

[122] The intensity of noise was measured by the Western Electric 3A Audiometer which measures the intensity of either a pure tone or of a complex noise in units of "sensation" or "audibility." In this experiment the intensity during the noisy period was 50 units, which is approximately average for the New York office; during the quiet period 40 units.

PLATE VII. A. *The effect of noise on energy expenditure is determined by analysis of the air exhaled under quiet and noisy conditions. The mask, with separate inlet and outlet valves, fits over the mouth and nose. The air of the room is inhaled, and the exhaled air, having passed through a short tube, can be collected and analysed. An operator quickly becomes accustomed to the mask; for nine months each of three subjects slept with a similar mask strapped to his face.*

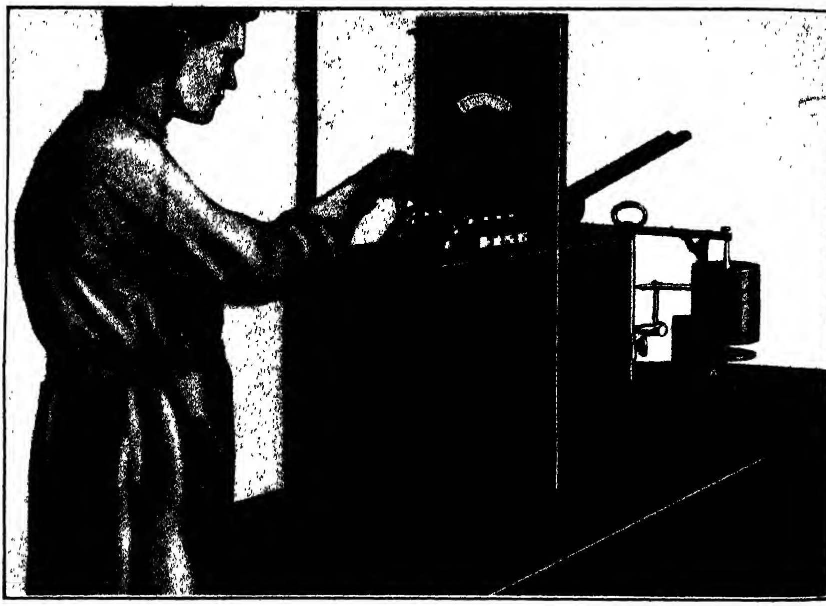
Of special interest are—the wall of Acousti-celotex in the background; the calculograph for recording time and the electrical connections to the noiseless typewriter for measuring output. The typist maintained a speed of 150 words per minute.

B. *The exhaled breath is collected in the Douglas bag on the table. All but the small sample required for analysis is passed through the meter behind it, and the amount exhaled per minute is determined. The sample is analysed in the Orsat apparatus to which the experimenter is pointing. On the wall is the Tycos Psychrometer which records dry-bulb and wet-bulb temperatures.*

(*After Laird*)

PLATE V

PLATE VIII



Apparatus employed in the study of susceptibility to Monotony

(After Wunderlich)

of noise upon white rats as well as upon man, are being carried on both to investigate the exact nature of these effects and the validity of the hypothesis. However, as interesting as these findings may be, the results of a laboratory experiment, in which conditions of work differ markedly from those found in the industrial plant, cannot be applied directly to the plant situation, although they may have considerable bearing on the orientation of industrial studies and on the development of techniques to be employed in such studies.

The effect of noise on the production of typists under actual office conditions has been examined by Kornhauser [123] who observed the records of 4 typists engaged in turning out routine sales letters in a 4-day experiment conducted in a large Chicago office. Two of the girls spent the first 2 days in a comparatively quiet office and the last 2 days in a noisier office. This order was reversed for the other 2 subjects of the experiment.

Records of the work showed that 3.2 per cent more lines were written under quiet conditions. However, the wasted lineage, in the form of discarded letters, was 23 per cent greater in the quiet than in the noisy room so that the net figures for total completed letters favored the work under noisy conditions by 1.5 per cent. In the noisy room there were 1.7 per cent more errors than in the quiet room.

In order to measure the effect of noise upon feeling tone the typists were asked to make a report at the end of each half-day on the following scale.

6. *I feel that I have been working very much harder than usual.*
5. *I feel that I have been working considerably harder than usual.*
4. *I feel that I have been working a trifle harder than usual.*
3. *I feel that I have been working about as hard as usual.*
1. *I feel that I have been working not nearly as hard as usual.*

The average rating for the noisy office was 3.1 and for the quiet office 3.3, indicating no difference in feeling tone.

Relative loss of efficiency under the two conditions was examined by noting variations in speed and for number of errors for successive half-hour periods. No decrease in speed was found in either condition. There was an increase in errors in both but no significant difference between the quiet and noisy conditions of work. The results of this experiment are somewhat affected by the fact that the difference in noise between the two rooms was not extremely large and by other variables, such as number of people passing through each of the two rooms. Kornhauser suggests that "an important psychological element to be considered in accounting for the present results is the fact that the work studied was highly automatic or stereotyped. The average typists, as indeed, any experienced worker

[123] A. W. Kornhauser, "The Effect of Noise on Office Output," *Ind. Psych.*, 2 (1927), pp. 621–22.

in a specific operation, has developed a certain habitual level of performance which is maintained under all ordinary conditions, whether favorable or not. It is probable that noise decreases efficiency more in activities which are less stereotyped or which greater thought and concentration of attention are involved." [124]

The highly specific character of findings in this field and the danger of generalizations on the effect of noise upon individual output and welfare are well illustrated in the contradictory evidence upon the effect of noise upon human efficiency appearing in a number of English studies.[125] In an unpublished study by Vernon and Warner [126] a loud phonograph, metronome ticks, electric bells, etc., were employed to determine the effect of such noises upon performance upon an arithmetic test. The rate of work was accelerated 1.3 per cent by the tick of the metronome and 2.6 per cent by the electric bell. Following a number of preliminary studies by Lorrain-Smith, Pollock [127] studied the effect of noises upon a repetitive manual task and upon a simple mental test (word building). In general, work was less efficient with noise, whether continuous or discontinuous in character, but the difference was not found to be statistically significant. Continuous noise appears to have a more stimulating initial effect than discontinuous work. No data is presented on the physiological cost of noise, or the effect upon physical efficiency. Although the objective effect is small, all subjects reported discomfort under noisy conditions of work.

In a further test involving meaningful and meaningless noise, the meaningful noise appeared to decrease the disturbing effect. Summarizing the results of the various studies, the following conclusions are drawn on the effect of noise:

"(1) No experimental evidence is available to show that automatic performance is adversely affected by noise or by vibration.

"(2) Nevertheless, except with certain 'meaningful' noises, there is a wide agreement that both noise and vibration are 'disagreeable' or 'uncomfortable' accompaniments of work.

"(3) A continuous noisy background often appears to have an initial stimulating effect, and this taken together with (2) appears to indicate that the noise should be regarded as an adverse condition which is met by an unwitting increase of effort.

"(4) With constructive work involving mental effort fairly consistent slight deterioration is observed, particularly in continued effort. Although so far as the experiments go, the deterioration is barely or only just statistically significant, it may be 'psychologically' significant. The consistency of the small deterioration seems to point to this.

[124] *Ibid.*, p. 622.
[125] *Eleventh Annual Report*, Ind. Health Res. Bd., London, (1931), pp. 62–65.
[126] *Ibid.*, p. 62.
[127] *Ibid.*, p. 63.

"(5) Discontinuous noise is more subjectively disturbing than continuous noise; 'meaningful' noise may be more or less disturbing than 'unmeaning' noise according as it is interesting or familiar."

In the industrial situation Weston and Adams [128] have examined the effect of noise on the output of 6 operatives in a weaving shed. On alternate weeks of the experiment the operatives guarded themselves against noise by using "ear defenders." Five of the 6 operatives showed a slight increase in output during these weeks, the average increase for the group being 1.6 per cent. An interesting by-product is the finding that after becoming accustomed to the "ear defenders" the operatives prefer to work with them because of the subjective feeling of greater restfulness present under these conditions. Many more studies of this type are needed before valid conclusions can be drawn on the effect of noise upon individual efficiency and welfare in the industrial plant.

[128] *Ibid.*, p. 65.

XXIII. MACHINES AND MONOTONY

"As once the microcosm Man against Nature, so now the microcosm Machine is revolting against Nordic Man. The lord of the World is becoming the slave of the Machine, which is forcing him—forcing us all, whether we are aware of it or not—to follow its course. The victor, crushed, is dragged to death by the team." [1]

O. Spengler—*Man and Technics*

A problem of utmost importance in the present-day era of industrial specialization is the effect of repetitive work upon the worker's welfare and efficiency. "I watched a man," writes Pound,[2] "shove metal rings across six inches of space, to a guide from which they were taken automatically through the machine, emerging slotted some seconds later, without more human ado. That was his job from morning until night, his pay depending upon how many slotted rings passed inspection. Eyes concentrated on his little platform, one hand moving thus, the other so, in unending repetition; he missed not one revolution of the wheels which were grinding out his life, even as they ground out the goods. Economically he was part of the machine—an automatic feeder who chanced to be flesh-and-blood and mind."

On such a task the worker does not direct and control the machine, but helps it out at points where the machine process remains incomplete. As the attendant of the machine he surrenders himself to its rhythm and time. "He supplements whatever human faculties the machine lacks, whatever imperfection hampers the machine in the satisfaction of its needs.—If it lacks eyes, he sees for it; he walks for it, if it is without legs; and he pulls, drags, lifts, if it needs arms. All of these things are done by the factory worker at the pace set by the machine and under its direction and command. A worker's indulgence in his personal desires or impulses hinders the machine and lowers his attachment value." [3]

Not only as an attendant to the automatic machines, but on assembly work on the moving belt, in office work on the typewriter, on the bookkeeping machine and calculating machine, the unceasing repetition of the same task is the order of the day. The substitution of uni-

[1] O. Spengler, *Man and Technics*, New York, 1932, pp. 90–91.
[2] Arthur Pound, *The Iron Man in Industry*, Boston, 1922, p. 42.
[3] H. Marot, *The Creative Impulse in Industry*, New York, 1918, p. 4–5.

formity for variety, of an assigned standard procedure and sequence of operations for choice of activity in the working situation, represents perhaps the major change involved in the transition from the pre-industrial to the modern era.

It requires only the barest comparison to recognize the scope of this change. Picture, for example, the work of the carpenter of the eighteenth century, sawing the wood, finishing the joints, assembling and gluing the parts of a piece of furniture, painting and polishing it, and finally delivering the piece, and discussing its merits with his customer. In contrast is the worker in the modern furniture plant—operating a saw, or sandpapering, or placing into position one item of a manufactured piece. For hour after hour he performs the same operation, frequently without any knowledge of the shape or purpose of the finished product, unable perhaps to stop for a moment of conversation for fear of holding up the progress of work on the belt which he must tend.

CONFLICT BETWEEN REPETITIVE WORK AND INSTINCT

So complete is this transition from age old traditional methods of work that it seems reasonable to raise a question concerning both the inherent suitability of mankind for such repetitive work, and its effect upon the mental development and temperamental adaptability of workers engaged in it. This question has been raised in many polemics on the subject. The chief criticism against repetitive work has come from economists and psychologists who point to an inherent antagonism between such kind of work and certain of the basic *instincts* of the human race. Their contention is that the behavior of mankind in industry, as in every other affair of life, is rooted in his unlearned, original equipment of *instincts,*[4] and that any tendency to run markedly counter to these can result only in disaster.

It is unnecessary in this text to enter into a detailed discussion of the nature of instincts, generally covered in elementary texts on psychology.[5] It will be recalled, however, that the instincts are looked upon as basic organic sets or psycho-physiological predispositions

[4] T. Veblen, *The Instinct of Workmanship,* New York, 1914, pp. 307.

[5] See Chapter XXV, pages 565–68.

(a) "We may define an instinct as an inherited or innate psycho-physical disposition which determines its possessor to perceive, and to pay attention to, objects of a certain class, to experience an emotional excitement of a particular quality upon perceiving such an object, and to act in regard to it in a particular manner, or, at least, to experience an impulse to such action." (Wm. McDougall, *An Introduction to Social Psychology,* London, 1908, p. 29.)

(b) "Instinctive behavior comprises those complex groups of co-ordinated acts which, though they contribute to experience, are, on their first concurrence, not determined by individual experience, which are adaptive and tend to the well-being of the individual and the preservation of the race; which are due to the co-operation of external and internal stimuli; which are similarly performed by all members of the same more or less restricted group of animals; but which are subject to variation and to subsequent modification under the guidance of individual experience." (C. L. Morgan, *Habit and Instinct,* London, 1891, pp. 350.)

toward particular forms of behavior. They are not determined by individual experience, but form part of the original nature of man. These natural proclivities are hereditary in character, and represent tendencies toward behavior which have remained deeply embedded in the present representatives of the human race as a result of a long process of selection—of adaptation to environment.

The instincts are the motivating forces; they are the energizing forces underlying human conduct. They are the prime movers in human behavior. The general function of instincts is adaptive, to promote the well-being of the individual and to preserve the race. Instincts are supplemented by intelligence and are ofttimes, in the case of the individual, modified to some extent by the environmental forces which play upon him. At the same time, the continued participation in a form of activity which runs markedly counter to the purpose and direction established by the instinctive urges of the race creates tension that may be serious in its consequences to the individual.

"For mankind as for the other higher animals, the life of the species is conditioned by the complement of instinctive proclivities and tropismatic aptitudes with which the species is typically endowed. Not only is the continued life of the race dependent on the adequacy of its instinctive proclivities in this way, but the routine and details of its life are also, in the last resort, determined by these instincts. . . . Human activity, in so far as it can be spoken of as conduct, can never exceed the scope of these instinctive dispositions, by initiative of which man takes action. Nothing falls within the human scheme of things desirable to be done except what answers to these native proclivities of man. These native proclivities alone make anything worthwhile, and out of their working emerge not only the purpose and efficiency of life, but its substantial pleasures and pains as wells." [6]

There is no agreement among psychologists with respect to the number and character of instincts. At one extreme is a classification of 4 basic instincts by Watson, and at the other an arrangement into over 50 instinctive predispositions by James. The classification by Tead [7] of ten major instincts can serve as an example of the way in which these are generally grouped:

1. *Parental Instinct*
2. *Sex Instinct*
3. *Instinct of Workmanship*
4. *Instinct of Acquisitiveness*
5. *Instinct of Self-Assertion*
6. *Instinct of Self-Abasement*
7. *Herd Instinct*
8. *Instinct of Pugnacity*
9. *Play Impulse*
10. *Instinct of Curiosity*

The instinct with which the repetitive work of the modern industry seems to come most seriously and most frequently in conflict is the instinct of *workmanship*, or the *creative instinct*. According to those who view this conflict seriously, the individual is endowed with an urge for

[6] T. Veblen, *op. cit.*, p. 1.
[7] O. Tead, *Instincts in Industry*, New York, 1918, p. 11.

creative experience in his work. There is a desire to be actively associated with the preparation of the product in its entirety and with the use of that product. The specialization of modern industry allows no opportunity for the display of this creative impulse—of the instinct of workmanship. The worker engaged in the unending repetition of the same task, his interest centered upon the single bolt on the assembly line, upon the single operation of tying a torn thread on a spinning machine, finds no satisfaction of the urge toward active association with the finished product.

As a reaction to this unending monotony he seeks *escape*. This may take the form of an absorption with the few flowers or the few vegetables raised in the back yard of his suburban home. More often, in the crowded conditions of the industrial city, the urge for escape expresses itself in a search for the staccato stimulation of the jazz orchestra, the lurid cinema film, the bright lights and the gay inconsequential amusements of Coney Island and the side show of the circus. In the rise to success against adversity of the moving picture hero, in the escapades, in million dollar settings, of his favorite moving picture "queen," the worker finds satisfaction for the absence of creative experiences in his work. Over-fatigued by the very specialization of the work itself, or as a result of limitations in intellect or interest, satisfaction is not sought in the creative experience of home, of the arts, of reading, but in more superficial and titillating substitutes for creative experiences.

Unfortunately, compensation for thwarted instincts does not always take this relatively harmless form. At times the mind of the worker, freed by mechanization from attention to his task, indulges in pessimistic day-dreaming [8] on his thwarted hopes. This leads to dissatisfaction with work, mental disturbances, and perhaps a complete disintegration of personality. At its best, it creates strains and stresses which grossly affect the physical and mental well-being of the worker. Directed into group activities, this dissatisfaction helps to lay the foundation of mass industrial unrest. The harmonious relations between workers and management, the very foundations of industry, are shaken by the conflict which often arises from this reaction to monotonous repetitive work of modern industry.[9]

Repetitive work has been criticized not only because it conflicts with instinctive tendencies, but because it may limit the very mental alertness of the individual and through it curtail his contribution to social development. The statement of President Hoover that "the vast, repetitive processes are dulling the human mind" is quoted [10] in substantiation of this viewpoint. To this is added his plea that "we must take account of the tendencies of our present repetitive industries to eliminate the creative instinct in their workers, to narrow their fields of

craftsmanship, to discard entirely the contributions that could be had from their minds as well as from their hands. Indeed, if we are to secure the development of our people, we cannot permit the dulling of these sensibilities." Long habituation to a repetitive, machine-paced task, it is said, makes the worker less adaptable and less alert. It renders him less able to cope with a changing environment and less capable of contributing to its modification as an aid in the further development of the race—which, if the predictions are carried to their logical conclusions, is gradually descending to the level of the *robot* working under the direction of a few super-executives.

The influence of repetitive work is to be found not only in the dulling of mental alertness, but in increasing limitation of other modes of expression. Parker [11] complains bitterly of the submergence of aesthetic values by a machine civilization. He contrasts the small group of sallow faced clerks watching young Morgan issue from his Wall Street office with the riotous festivities of the City of Florence to celebrate the hanging of Giotto's painting in St. Mark's. In his complaint that, in spite of its vast production of goods, the United States has not yet produced a Michael Angelo, a Leonardo da Vinci, or an Andrea del Sarto is found another instance of the criticism of the machine age on the same grounds.

IN DEFENCE OF THE MACHINE AGE AND OF REPETITIVE WORK

Repetitive work and the machine age have not been without their defenders. So, for example, Dubreuil [12] questions the emphasis upon the dominance of machine over man in a mechanized task and the assumption that machine operation is generally accompanied by a depressed mental state. He cites in illustration of his viewpoint a sanding job at the White Factory at Cleveland. On this task, the workman directs a jet of sand, through an opening in the wall at the height of his hand, into a shed-like arrangement containing pieces to be cleaned. At times, he is required to stick his head through a screen-covered opening in the wall of the shed in order to observe the progress of his work. At such times only the operator's back and legs can be seen, and the impression he gives is of a man placed in an instrument of torture rivalling any employed by the Inquisition. Under these conditions the worker seems to lose his identity as a man and becomes a veritable portion of the machine which he is tending.

Dubreuil describes the sympathy awakened in him for this human appendage to the machine he was tending. At the same time, to test his impression, he asked for permission to work on this machine and changed places with the operator who had been assigned to it. "My impression," he writes, "was then extremely different from the one I

[11] C. Parker, *The Casual Labour and Other Essays*, New York, 1920, p. 58.
[12] H. Dubreuil, *Robots or Men*, New York and London, 1930, pp. 248.

had had while looking at the scene from the outside. I felt instantly that the tragic aspect, augmented and aggravated by my imagination, had completely disappeared. Occupied in watching the gradual whitening of the pieces, I thought no more of the aspect I might offer to anyone outside. I simply had to do a new job by particular methods and under peculiar conditions. Once more I learned to mistrust appearances, for a visitor perceiving me in that position might have experienced the same feeling I had previously felt while I recognized that my emotion was unjustifiable." [13]

There must be much industrial work, he writes, "that appears formidable to the uninitiate, while those who perform it look on it as entirely natural. The difference in point of view is important, and it is well to remember this when making judgments on industrial life."

With respect to *effect on mental alertness,* it has been pointed out that the automatic [14] machine and repetitive processes, requiring the minimum of attention, actually free the worker for the exercise of his mind. The substitution of intellectual pleasures for the interest in neo-primitive dancing to the tunes of a jazz orchestra and in the glamour of the million dollar movie becomes merely a matter of direction and training. It is to the development of an educational program to stimulate such substitution, rather than upon a critique of automatization in industry, that the attention of the social reformer should be directed. The outstanding feature of the machine is that intellectual interests can be pursued when the worker is engaged on his task to an extent impossible in hand work, upon which the attention of the worker must be continually concentrated.

In so far as general social and aesthetic values are concerned, mechanization and specialization of work are praised by its defenders as devices which accomplish work today what was formerly martyrdom to hundreds of thousands of human beings, and as aids in the wider dissemination of aesthetic standards. Mass production of cloth garments has relieved women who wore out their lives and eyes on spinning, weaving, sewing, and embroidery. Ugly, hardy clothes worn for years because of cost have been replaced, through the introduction of machine operations, by flowered dresses, woven of fine material, which even the poor worker can buy for his wife at the price of a day's work. In this way, into the life of the masses of the people have been introduced aesthetic values absent in the drab days of the pre-machine age. Other losses in social values are more than compensated for by the new aesthetic appreciations, the increased leisure, the easier conditions of daily life which the machine has made possible. Viewed from this angle, Ford, pictured by Dubreuil as the prophet of the machine age, becomes a benefactor of mankind who contributes both to the intellectual

[13] H. Dubreuil, *op. cit.,* pp. 110–11.
[14] *Ibid.*

stimulation of individual life and the enrichment of the social milieu in which he lives.

This discussion would be incomplete without a reference to another aspect of the problem which has been neglected by many critics of the machine age. The implication in many discussions of repetitive work is that such work is characteristic of the industrial era alone. As a matter of fact, long before the appearance of machines many tasks had already become highly standardized and routine in character.[15] The hours and hours of polishing required in the preparation of flint arrowheads used by primitive tribes must have been extremely monotonous work. Hand weaving, with the repeated throw of the shuttle from side to side, has in it all of the elements of the repetitive work of the machine age. It is true that in these earlier days the pace was set by the worker and the distribution of the activity throughout the day was also independently determined. Florence has pointed out that "when the craftsman who works at home feels tired of his task he can 'knock off' for a few minutes, and gain a fresh incitement. If he feels slack in the morning he can work in the afternoon and evening, or vice versa. If his work gets on his nerves he may walk into his garden, or occupy himself about the house, away from the ordinary conditions of his work. To the industrial employee all such variations are impossible. Whether he is working in factory, office, mine or shop, he must 'keep on the job'; he cannot work when work is congenial and stop when he feels the need of rest. There is a definite routine imposed from outside." [16] At the same time, many of the essential characteristics which today are referred to the machines and believed to be characteristic of the machine age alone were undoubtedly characteristic of the everyday activity of not only the workers in civilized races but of primitive tribes of today and of the prehistoric age. Moreover, in thinking, for example, of the activities of workers in the period of the Renaissance, we tend to ascribe to *all* the joy in creative experience which was present probably only in the work of the master craftsmen. Even in that period, as in earlier periods, the work of the helper was unquestionably routine and probably monotonous. It is quite possible that the great bulk of workers in all ages has had no more interest in creation or greater opportunity for creative experience than the large mass of unskilled and semi-skilled workers employed in modern industrial plants.

The attitude of the industrial engineer on the effect of mechanization on men has been well expressed by Person, who may be fairly described as the dean of scientific management in the United States. "We have begun seriously to question our first assumptions concerning the effect of machine tending on the individual," writes Person. "These assump-

tions were derived principally from the reports of observers who were essentially artists and whose judgments appear to have been highly colored by poetic imagination. Their sweeping generalizations have not been verified by the more numerous and sustained observations of those intimately concerned with industry. Without question, fatigue, monotony, and other undesirable elements are present in modern machine work, but apparently not so much for workers operating the machines, as for artists watching the machines being operated. And what is more to the point, there are probably no more, if as many of these undesirable elements in the tending of a typical 1930 machine as there were in operating the primitive machine which performed the same function. Maggie at the modern spinning frame of a great factory probably suffers fewer discomforts than her great-great-great-grandmother at the spinning wheel in her colonial kitchen." [17]

THE EXTENT OF REPETITIVE WORK

The incidence of monotonous work upon human adaptation and adjustment is another factor to be considered in this discussion. In a study of occupations in a brassware and munition factory by Florence [18] 35.8 per cent are shown to involve uniform processes of a type which tend to develop in the worker a feeling of monotony. It is interesting to note that certain of these are clerical occupations involving "brain work." The analysis suggests that monotonous work does not occupy such a large proportion of the industrial activity as is ordinarily believed. At the same time, the amount of it which is present, combined with its growing importance in industrial life, makes monotony one of the major problems of industrial psychology.

Regardless of the *a priori* position which one may assume, the effects of repetitive work upon human nature, and the adaptability of mankind to this type of work are questions for analysis by the psychologist. These questions have been made the subjects of study in a number of experimental investigations conducted both in the laboratory and in the working plant. In these studies an attempt has been made to investigate the following problems:

1. *The characteristics of monotonous work.*
2. *The incidence of individual differences in susceptibility to monotony.*
3. *The influence of uniformity and variety of work upon production and upon the state of mind and adjustment of the worker.*
4. *The extent of individual maladjustment in repetitive work.*

THE CHARACTERISTICS OF MONOTONOUS WORK

1. Boredom and Restlessness

The chief characteristic of monotonous work is the unpleasant feeling that the task arouses in the individual. A feeling of boredom and an increasing feeling of tension as the work progresses represent the subjective characteristics of monotonous work. Objectively, this feeling of monotony is characterized by restlessness, indicated in a frequent shift of position, by yawning, and by verbal expressions of dissatisfaction with the work on the part of the worker. The nature of subjective attitudes of the worker when monotony is experienced is well illustrated in the introspective observations obtained from subjects in a laboratory experiment on repetitive work by Wyatt, Fraser, and Stock.[19]

Subject A. "Usually I was able to work quite satisfactorily during the first hour but afterwards began to feel bored. At this stage the knowledge of having to stick at the job for another 90 minutes was very unpleasant, and although I tried different methods to keep the work from dragging, the efforts were not very successful. I began to feel a certain amount of relief when I thought the end of the test was near, and on such occasions had a feeling that my output improved. Shortly before the end of the period all unpleasant feelings disappeared and I felt quite normal."

Subject B. "I seldom enjoyed the tests and usually found the work tedious. The experiments often seemed very long, and after the first hour of work I experienced an impulsive desire to say something to the experimenter, or to get up and look through the window. About the middle of the test I sometimes became somewhat stupefied, but towards the end began to 'sit up' and take notice."

Somewhat similar, although less detailed observations have been obtained by the same investigators [20] from factory workers in the course of plant investigation on monotony. The nature of these observations is illustrated in the remarks made by workers engaged in winding filaments in electric lamps.

Worker A. "I like the work fairly well but sometimes get bored. I begin to look forward to going home. Sometimes I feel like a change and go for material."

Worker B. "I like the work as a whole but sometimes feel bored, especially in the afternoon. Then I feel like walking about or talking."

Worker C. "I get fed up at times, usually in the morning. I often find an excuse to walk about."

[19] S. Wyatt, J. A. Fraser, and F. G. L. Stock, "The Effects of Monotony in Work," *Ind. Fat. Res. Brd. Rep.* No. 56 (1929), p. 44.

[20] *Ibid.*, pp. 44–47.

2. *The Monotony Curve*

Work accompanied by monotony is characterized not only by a feeling of dissatisfaction and tension, but by a distinct change in the rate and regularity of production. This includes, primarily:—

1. *A drop in the rate of work in the middle of a working spell.*
2. *An increased variability in the rate of work.*

In work, in general, the rate of work and the total amount of production tends to increase during the middle of the working spell. There is a warming-up period at the beginning of a working spell, a period of relatively high production during the middle of the spell followed by a gradual and consistent drop in the rate of production. Output distributed in this way during an ordinary working day gives a production curve like that shown in Figure 61, which is characteristic for many kinds of work. In addition, in daily production not characterized by monotony the rate of work or production tends to be fairly regular over short periods as, for example, one-quarter-hour or five-minute periods of the working day.

Experimental studies conducted both in laboratories and in industrial plants indicate that one feature of monotony in work is the tendency for production to *fall* instead of to rise during the middle of the working spell.[21] "Boredom causes a reduced rate of working which is particularly noticeable about the middle of the spell. This decrease usually lasts from one to two hours, and during this time the average reduction in the rate of working varies from five to ten per cent. It is followed by a steadier and improved rate of working as the end of the spell is approached." According to Myers,[22] "the worker comes to his task feeling ready to go ahead with it, slows up in the middle of the spell as he becomes bored with the work and speeds up at the end of the day in anticipation of its end." He thus produces a curve absolutely inverse in shape to that of the normal working curve.

In addition, the production from period to period in monotonous work tends to be highly irregular.[23] "Boredom causes a more *variable rate* of working, which is characterized by repeated fluctuations in the time taken to complete consecutive units of output."

Wyatt [24] has made a detailed analysis of the psychological changes which account both for the decreased rate of production and the increased variability of work. At the beginning of a working spell, the worker is able to maintain a satisfactory rate of production. As he continues at the repetitive task a desire for change appears. This makes necessary an increase in the effort required to maintain the desired efficiency. It also produces a tendency toward an alternation of

[21] *Ibid.*, p. 42.
[22] C. S. Myers, *Industrial Psychology in Great Britain*, London, 1926, p. 71.
[23] S. Wyatt, J. A. Fraser, and F. G. L. Stock, *op. cit.*, p. 42.
[24] S. Wyatt, "Boredom in Industry," *Pers. J.*, 8 (1929), 161-171.

spurts and relaxation in work. The combination of these conditions brings about, in the middle of the working spell, both in the case of a morning and of an afternoon period of work, a reduction in the rate of work associated with an increase in variability of rate. Toward the end of the morning or afternoon the rate of work may again increase somewhat and almost invariably becomes more uniform. This results from the anticipation of the end of the work. The consciousness that the work will soon end stirs up activity and produces an actual improvement in the rate and regularity of production at a time when, from the viewpoint of physical fatigue, the worker should be expected to show decreased efficiency. The significant fact is that *such changes in the rate and variability of production, represented by a change in the shape of the work curve, appear only in the case of workers who express boredom and dissatisfaction with repetitive work.*

Examples of such "monotony" curves are to be found in an extensive laboratory and plant investigation by Wyatt, Fraser, and Stock.[25] The chief feature of this study was the analysis of production on diverse operations in comparison with introspective reports of operatives. In all, 49 operatives were concerned in this inquiry, engaged in six different kinds of repetitive work. Among these were two types of *filament winding* and an *inserting* process employed in the manufacture of electric lamps. These tasks involved a minimum of muscular effort combined with fine muscular co-ordination, control, marked concentration of attention, and, in some instances, sensitivity of touch. The task of *wrapping soap* brought to the operative by a moving belt represents the fourth operation studied. In addition, there was included the job of *chocolate packing,* a little more varied than that of soap wrapping, and the operation of *tobacco weighing.*

The industrial investigation was supplemented by a laboratory study of bicycle chain assembling and of rug making. In the former, four subjects trained in psychological research worked continuously throughout several periods of two and one-half hours each and furnished introspective records of changes in mental attitude in the course of work. In another experiment eight girls were employed for a period of seven weeks in making woolen rugs by inserting pieces of wool through holes in a canvas background. The hours of work were from 9:30 to 12:30 and from 2 to 5, and the girls were paid on a piece rate basis.

In the industrial investigations no more than one or two operatives were observed at a time, and different operatives were observed on successive days. The period of observation devoted to each worker seldom exceeded 6 days, but there are indications that the results would not have been appreciably increased by an extension of time. Operatives were frequently questioned regarding their attitude toward the conditions of work, especially with respect to the effects of uniformity.

[25] S. Wyatt, J. A. Fraser, and F. G. L. Stock, *op. cit.*

Questions were phrased in different forms in arriving at the truth concerning operative's feelings of boredom and fatigue. The replies of these operatives, extracts of which are cited on page 520, showed that most of the workers suffered from a feeling of boredom or monotony, particularly at about the middle of the working spell. As a matter of fact, of the 49 operatives questioned, only 13 were able to state that boredom was seldom or never experienced.

The character of typical daily production curve of workers who complained of the tiresome and boresome features of the task, as compared with those who experienced no such feelings, is shown for tobacco weighing, chocolate packing, and soap wrapping in Figure 73.

Each curve represents the average rate of work during each five-minute period of a composite day (broken line), while the general trend of the curves is shown by the continuous line. The latter is plotted by averaging the results of every seven consecutive five-minute periods. Moreover, each curve is a composite curve obtained by combining the average results obtained at corresponding hours on different days. The curves on the left are those of operatives who complained of being bored with the work; those on the right are curves of workers who, in general, liked the work and did not find it monotonous.

A comparison of the two sets of curves shows that in the case of operatives who experienced the feeling of boredom there is a marked dip in the curve during the middle of both the morning and afternoon working spells. In addition, there is greater variation in the lengths of the dotted lines, indicating the rate of production in five-minute periods, than appears in the case of the workers who did not experience monotony. The output of the latter tends to increase during the middle of the working spell, while the output of the former tends to decrease, as well as to show greater variability throughout the period of work. Another interesting difference is the tendency for the rate of production of the workers who experience boredom to show a slight increase at the end of the working spell. In other words, the daily production curves of workers experiencing a feeling of boredom have the characteristics of the monotony curve described in an earlier paragraph.

Curves obtained in the course of laboratory experiments in connection with the same investigation exhibit similar characteristics in the case of workers who became bored and restless in the course of performing the repetitive operations. That boredom, rather than fatigue, is the responsible factor for changing the shape of the curve receives support from the fact that the results show little difference in rate of production between morning and afternoon spells of work. In other investigations it has been found that when fatigue is predominant, the rate of production during the afternoon spell is usually less than during the morning. This is evident in the typical daily production curve shown in Figure 61. In the case of the present investigation there was found little difference in rate of output and in total output between

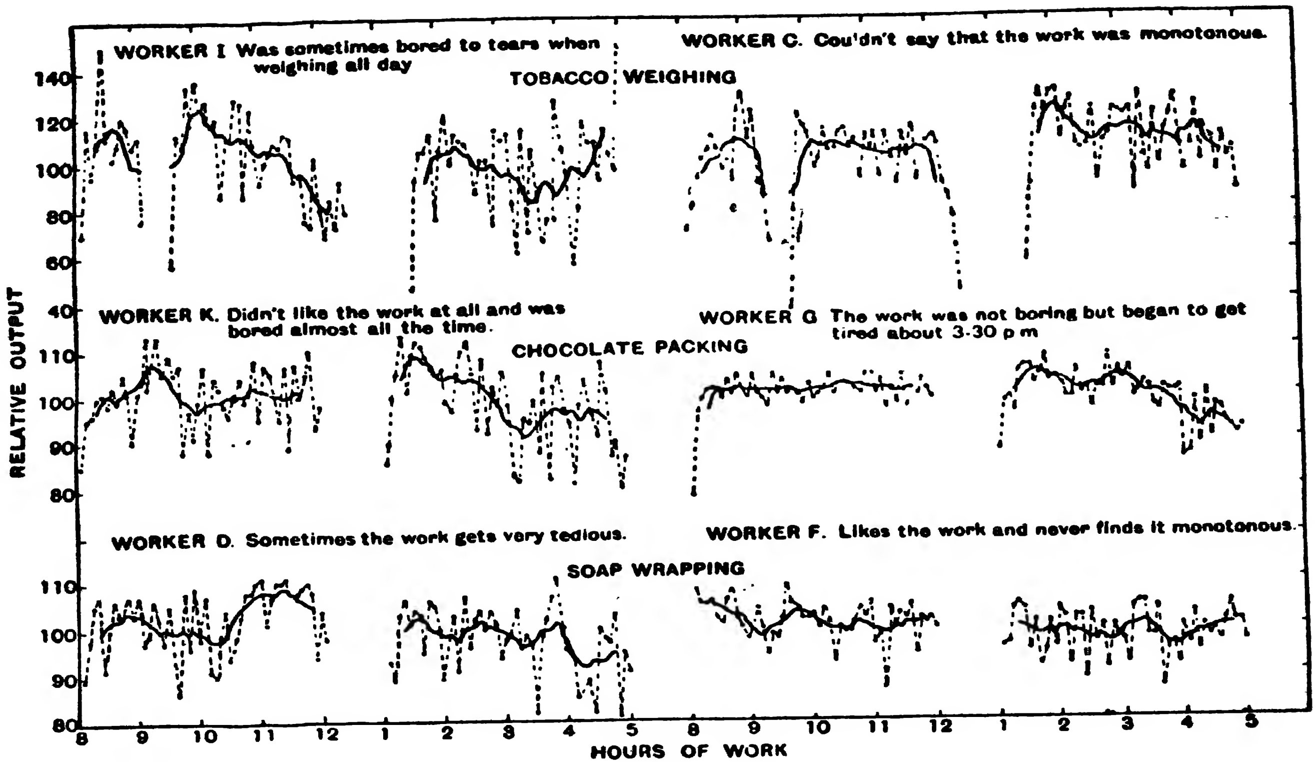


FIGURE 73. *Output curves obtained when boredom was experienced (left half) and almost absent (right half) in different industrial processes.*
(After Wyatt, Fraser, and Stock)

morning and afternoon spells. As a matter of fact, in some instances, an increase in output was observed, particularly at the end of the afternoon working spell, when the worker was stimulated by an anticipation of the end of the day's work.

The depressing effects of boredom on the rate of work is also brought out very clearly in Figure 74, obtained in a laboratory experiment on bicycle-chain assembling. In this experiment it was possible to obtain a more detailed introspective statement of the mental attitudes of the

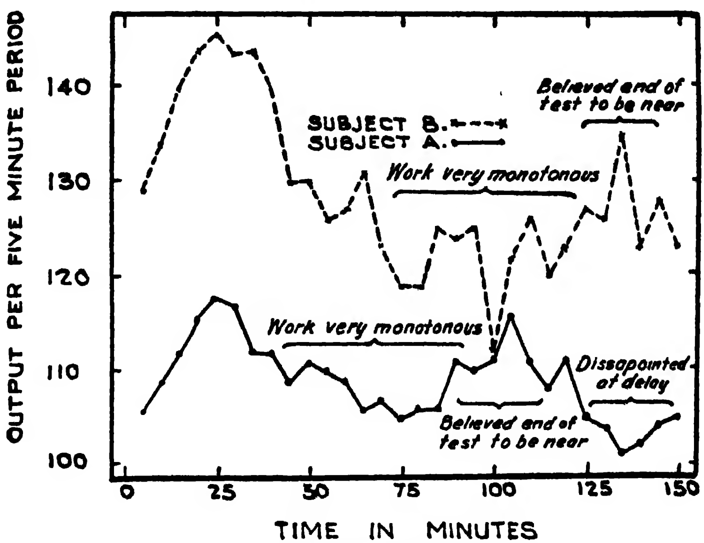


FIGURE 74. *Rate of work in comparison with subjective states during monotonous work.*

(*After Wyatt, Fraser, and Stock*)

workers. Here again is to be seen the dip in the production curve, associated with the feeling of monotony, and the spurt in rate of production when the end of the working period is thought to be near.

The characteristics of monotonous work are brought out even more distinctly in Figure 75, showing the rate of production in five-minute periods of subjects employed on the laboratory task of assembling bicycle chains. Inasmuch as the conditions of the laboratory experiment are in general more exacting than those of industrial work, the effect is particularly noticeable. The essential features of the process employed in this laboratory investigation can be seen by reference to Figure 76. The process represents a typical repetitive operation, the same cycle of movements being repeated many thousand times during the course of a day.[26] The subject was seated in front of the disc A, which contained

[26] S. Wyatt, "Machine Speeds and Output," *J. Nat. Inst. Ind. Psych.*, 3 (1927), 406-414

eight pairs of shafts, B, on which were placed two links used in the manufacture of bicycle chains. The subject removed the nearest pair

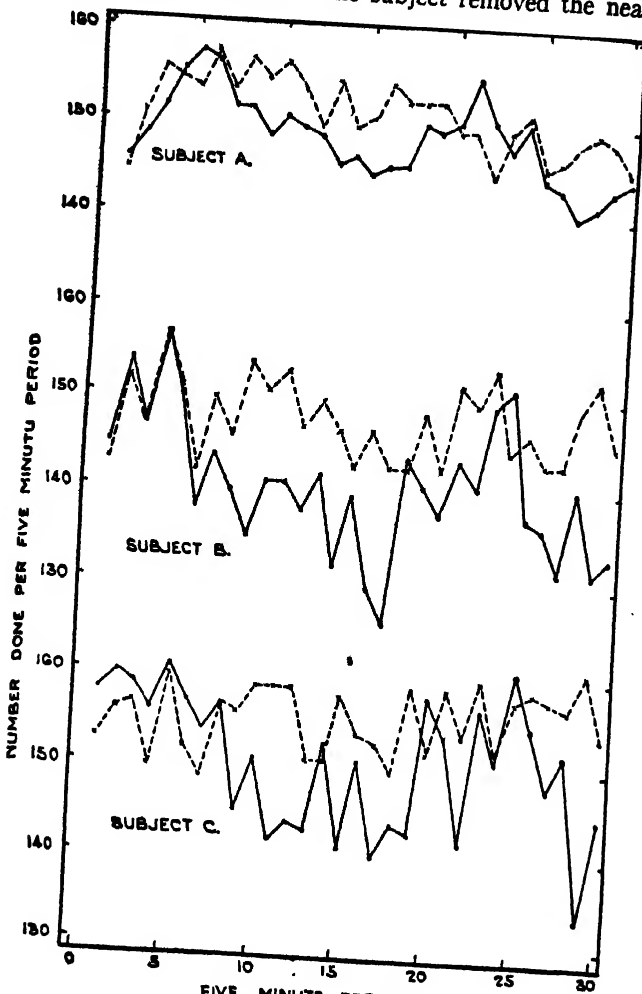


FIGURE 75. *Curves illustrating variations in the rate of working when boredom was experienced (continuous line) and almost absent (broken line). (After Wyatt, Fraser, and Stock)*

of shafts and links from the disc, took off one of the links, dropped it into a box, C, and replaced it by another which was taken from a supply on the left, E. The shafts and links were then replaced on the disc and the latter was moved by the subject through approximately one-eighth

of its circumference, after which the cycle of movements was repeated with the next shafts and links.

Three subjects (all male research workers) took part in these ex-

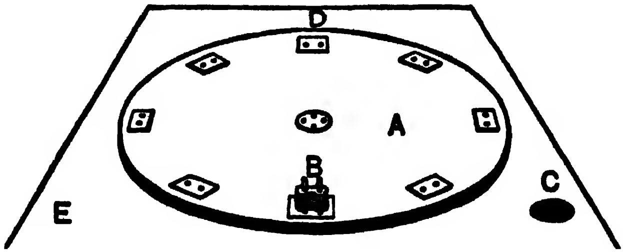


FIGURE 76. *Diagram of Mechanism Used in Bicycle Chain Assembling. (After Wyatt)*

periments, and once a week each of these worked continuously during a spell of two and a half hours.

The introspective reports for the three subjects whose results are shown in Figure 77 are as follows:

Subject A—*Continuous line*—Stated that he was very bored about the middle of the spell but recovered when he thought the end of the work was near.

Broken line—Seemed to work very well all the time and experienced little or no boredom.

Subject B—*Continuous line*—Began to feel bored after the first 25–30 minutes. Feeling increased in intensity but disappeared when the end was believed to be near. Disappointed when the signal to stop was not given.

Broken line—Slightly bored about half-way through the spell, but on the whole time passed fairly pleasantly.

Subject C—*Continuous line*—Found the work very distasteful and was bored most of the time. Felt better near the end and thought rate of working improved.

Broken line—Seemed to work very well all the time and was less bored than usual. Conditions were a little dreary during the second hour.

The curves given in Figure 75, combined with these introspective reports, show clearly that boredom tends to be accompanied by increased variability of work. This is also evident in the fact that the standard deviations from daily averages, shown in Table 63, are greater when boredom is experienced than when it is absent.

In the industrial processes variations in the rate of working, expressed in terms of standard deviations of the five-minute readings from the daily average, were also greater for those workers who complained of boredom. (Table 64)

TABLE 63

Subject	S. D. Continuous Line (Much Boredom)	S. D. Broken Line (Little Boredom)
A	7.29 ± .62	3.54 ± .31
B	7.11 ± .62	4.01 ± .35
C	4.25 ± .37	3.64 ± .32

TABLE 64

PROCESS	MUCH BOREDOM		LITTLE BOREDOM	
	WORKER	S.D.	WORKER	S.D.
Winding (U)	F	8.72 ± .41	H	5.91 ± .28
Winding (H)	H	8.31 ± .39	D	6.39 ± .30
Inserting	E	9.23 ± .44	B	4.91 ± .23
Soap Wrapping	D	7.05 ± .34	F	4.47 ± .21
Chocolate Wrapping	K	6.83 ± .33	G	4.74 ± .23
Tobacco Weighing	I	19.44 ± .95	C	15.31 ± .75

(After Wyatt, Fraser, and Stock)

Findings from other experiments [27] corroborate the conclusions which have been drawn concerning the specific character of the production curve obtained when monotony is experienced. The evidence definitely favors the opinion that the onset of monotony is accompanied by changes in the rate and variability of production. An examination of the work curves makes possible a separation of the physical effects of work, in the way of fatigue, from the purely psychic feelings of boredom, conflict, and strain—characteristic of monotony—appearing in the case of some individuals when employed at a repetitive task and under allied conditions of work.

3. *Changes in Estimation of Time*

In addition to the changes in the course of repetitive work described above, the onset of monotony, according to some investigators, appears to be characterized by a tendency toward the *overestimation of time intervals* on the part of those engaged in monotonous work. Evidence of this is found in a laboratory experiment [28] in which two subjects were engaged in the repetitive task of sorting balls for a period

[27] H. M. Vernon, S. Wyatt, and A. D. Ogden, "On the Extent and Effects of Variety in Repetitive Work, *Ind. Fat. Res. Bd. Rep.*, No. 26, (1924), pp. 12.
S. Wyatt, "Studies on Repetitive Work," *Ind. Fat. Res. Bd. Rep.*, No. 32, (1925), pp. 44.
S. Wyatt, and J. A. Fraser, "The Comparative Effects of Uniformity and Variety in Work," *Ind. Health Res. Bd. Rep.*, No. 52 (1928), pp. 36.
H. M. Vernon, "On Certain Effects of Long Spells of Repetitive Work," *Brit. J. Psych.*, 16 (1926), Part 3.
[28] S. Wyatt, J. A. Fraser, and F. G. L. Stock, *op. cit.*, p. 20.

of two hours. At various stages of this period each subject was asked to estimate the length of time already spent on work. The results obtained are shown in Table 65. It is quite evident that each subject tends to overestimate time when an appreciable degree of boredom is experienced. Generally speaking S was found to suffer more from boredom than M. At every period his over estimations were greater than

TABLE 65

Estimation of Time by Two Subjects Engaged on a Repetitive Task

			TIME (IN MINUTES)				
Subject M . . .	Much Boredom . . .	Actual	35	55	70	90	105
		Estimated	25	50	80	105	120
	Slight Boredom . . .	Actual	35	55	70	90	105
		Estimated	25	45	65	95	110
Subject S . . .	Much Boredom . . .	Actual	30	50	70	90	100
		Estimated	30	55	85	110	120
	Slight Boredom . . .	Actual	30	50	70	90	110
		Estimated	25	50	75	100	115

(After Wyatt, Fraser, and Stock)

those of M. The fact that there are only two subjects in this investigation offsets the value of the results, but they indicate the trend referred to by other investigators.

Overestimation of time in the case of workers who experience a feeling of monotony has been explained on different grounds. Applying the findings of earlier experiments that the estimation of time intervals is determined by the amount of mental content [29] experienced during a period it has been suggested that overestimation is the result of the number and variety of ideas appearing in the mind of the worker, *where attention is not absorbed in the repetitive task*. In the case of such workers "time seems to be measured by the awareness or number of thoughts passing through the mind within a given period, and as these are both *numerous* and *disconnected* the day appears to be supercharged with ideas and its duration in consequence overestimated." [30] In the case of the worker whose attention is completely occupied neither by repetitive work nor by other interests, time seems to stretch on forever because of the tendency for attention to be centered on the amount of work still to be done and the amount of time still to be spent on work. At the same time, individuals who find interest in the task are free from a feeling of monotony and do not overestimate time because there is a free flow of mental activity not centered upon the

[29] M. Sturt, *The Psychology of Time*, London, 1925.
[30] S. Wyatt, "Boredom in Industry," *Pers. J.*, 8 (1929) pp. 161–172.

passage of time itself. "When an activity is accompanied by interest . . . the thought processes constitute parts of a unified whole and the individual is not consciously aware of the associated components. Time in consequence appears to pass comparatively quickly because of the uninterrupted flow of mental activity toward the desired goal." [81] This would, of course, also apply to those whose attention, in repetitive work, is not at all occupied with the task, but whose minds are completely taken up with a dissociated, but unified and interesting preoccupation.

The estimation of time in a repetitive task has been investigated by Lossagk.[82] In this study, the investigator examined the differences in time estimation by subjects while engaged in three activities of differing degrees of complexity. Approximately two hours were spent by each subject on each section of the study. The instructions were to indicate the passage of one minute at the end of each minute by pressing an electric contact.

Graphic records of time estimation were made under three different conditions.

1. When the subject was engaged in observing a point on a blank wall and in concentrating upon the passage of time.

2. When the subject was engaged in the simple and highly repetitive task of placing and withdrawing small wooden pegs under conditions which did not permit the counting of the pegs as an aid to the estimation of time.

3. In the third part of the experiment, the subject was asked to note the passage of time when engaged in the more complicated task of cutting and pasting a design. This task called for exact measurement and other refined operations.

The subjects included adults of both sexes and second year apprentices employed in an industrial plant. Among the adults were representatives of the supervisory staff of the plant.

The character of the findings are shown in Figure 79. *The length of the line represents the time actually elapsing during a period judged by the subject to be one minute in length.*

Figure 77D shows time estimates of one subject, a member of the engineering force of the plant, when engaged in looking at a blank wall. The section of the chart marked "å" reveals a pronounced *underestimation* of the passage of time, inasmuch as the length of the line almost invariably extends beyond the one-minute point. In addition, there is a great amount of variability in estimation from period to period, the estimates ranging from 1 to 3 minutes. The investigator suspected that this resulted from the fact that the highly intellectual subject

[81] *Ibid.*, p. 164.

[82] H. Lossagk, "Experimenteller Beitrag zur Frage des Monotonie-Empfindens," *Ind. Psychot.*, 7 (1930), pp. 101–107.

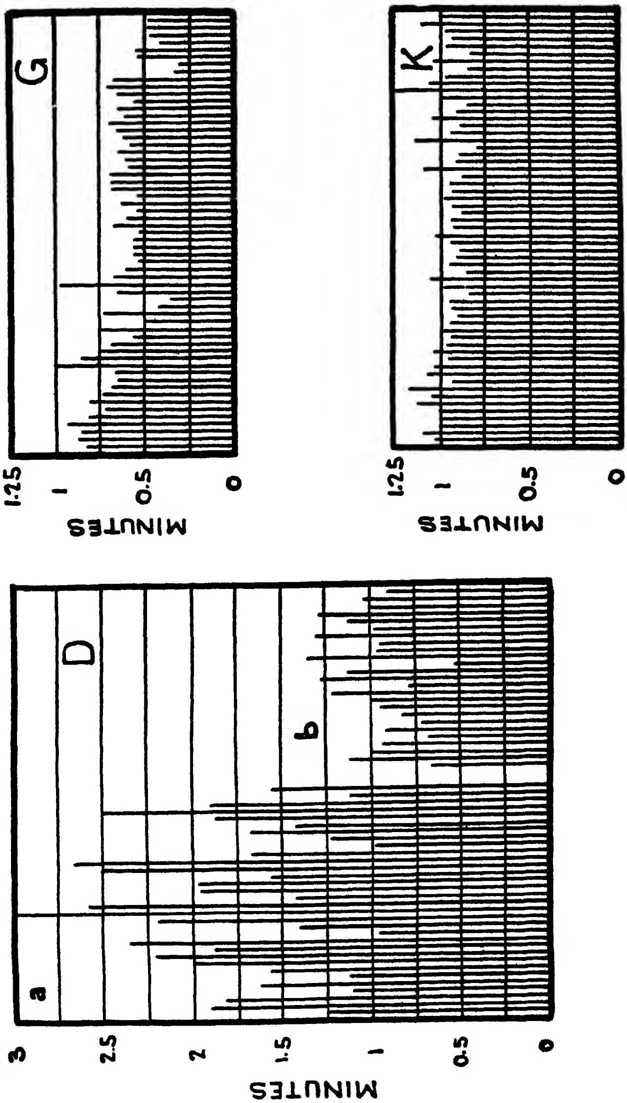


FIGURE 77. *Time Estimates under Different Conditions of Work.* (*After Lossagk*)

indulged in day-dreaming in the course of this experiment and completely forgot to press the contact key. In order to determine the influence of day-dreaming, the same subject was engaged in casual conversation while performing the first part of the experiment. The results obtained under these conditions are shown in part "b" of the chart. The length of the lines gives evidence of a more exact estimation of passage

of time and of a marked decrease in the variability of estimates when the mind of this subject is not allowed to wander off along its own path.

The estimation of passage of time by another subject while engaged in looking at a blank wall is shown in Figure 77G. This is a woman who had voluntarily sought transfer from a repetitive task to another task paying a lower wage because of the disturbing effect produced by the feeling of monotony arising out of the repetitive work. The figure reveals an overestimation of time by this subject combined with high variability. It is evident that time is passing very slowly, inasmuch as, on the average, the timing contact is pressed to indicate the passage of a minute when approximately only one-half a minuté has elapsed. These results suggest that this subject is incapable of employing her intellectual faculties to fill in the time in an environment almost completely free from stimulation. As a result, time appears to pass very slowly.

The most important feature of Lossagk's study is the analysis of the results of individual subjects and the comparison of groups of individuals engaged in different kinds of work. Figure 77K, showing the time estimates of an apprentice gazing at a blank wall, is presented as an example of a high degree of accuracy in time estimation combined with restricted variability, representative of a large group of *apprentices accustomed to repetitive work*. No estimate for a single minute period differs from the exact time by as much as 0.25 minute. The mental attitude of this subject, and of the group which he represents, can be expressed, according to Lossagk, in the statement, "Well it seems no different whether I sit at my bench or sit here with my head on my hand gazing at a blank wall."

The results of this group are contrasted by Lossagk with the tendency toward overestimation of time and with the greater variability of estimates, when engaged in looking at a blank wall, on the part of *apprentices unaccustomed to repetitive activity,* illustrated in Figure 77L. In addition, apprentices not accustomed to repetitive work tend to underestimate the passage of time and to exhibit a wide range of estimates in Part 2 of the experiment, involving time estimation when engaged on a simple repetitive task. This appears clearly in Figure 77R. On the other hand, apprentices accustomed to repetitive work show the same accuracy in estimating the passage of time in Part 2 of the experiment, i. e., when engaged on a simple, repetitive task as they do in the first part, i. e., when looking at a blank wall. This is evident in Figure 77M, showing the results of one apprentice, acustomed to repetitive work, in Part 2 of the experiment.

In the case of the highly complicated task of the third part of the experiment, apprentices with little experience on highly repetitive tasks again show a tendency toward underestimation of time, combined with a wide range of estimates. They appear to become so involved on the

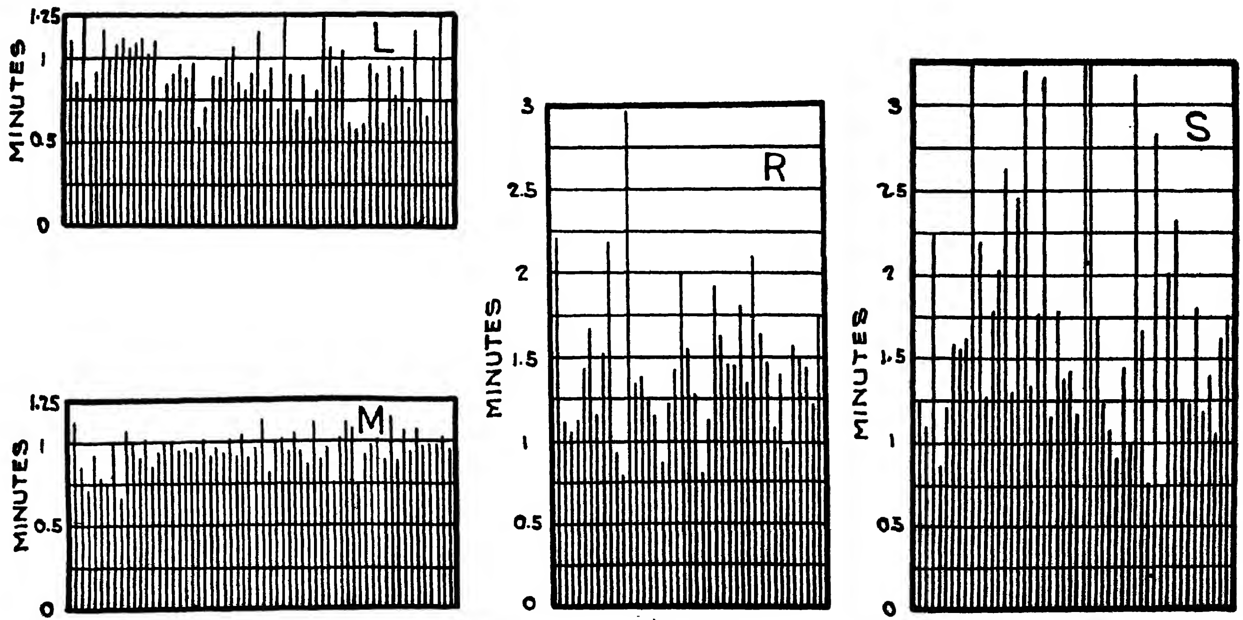


FIGURE 77. (Continued) *Time Estimates under Different Conditions of Work.* (*After Lossagk*)

requirements of this complicated task that they completely lose sight of the passage of time. This is clearly evidenced in Figure 77S, showing time estimates of an apprentice not accustomed to repetitive work when engaged in a complicated task. Apprentices accustomed to repetitive work exhibit in Part 3 of the experiment the same accuracy and low variability in estimates which appears in their case in Parts 1 and 2.

It is difficult, as Lossagk points out, to draw conclusions from these varied findings. The report on the experiment suffers also from a failure to provide as detailed a description of mental states as is found in the English investigation. In addition, the author fails to state the number of cases. For these reasons, both results and conclusions must be accepted with reservations.

Lossagk suggests that a tendency to *overestimate* time intervals indicates high susceptibility to monotony in the case of those who cannot occupy their minds with other activities when engaged in highly repetitive work, and where attention is not absorbed in the repetitive task. This appears to confirm the observations of English investigators.[38] At the same time, he points to the fact that in the case of individuals whose minds wander to other interests in the course of an apparently monotonous activity, time tends to be *underestimated*. Such an individual becomes so completely engrossed by other interests as to lose track of the passage of time. Upon these grounds this author advises against the use of absolute estimation of time as a criterion of monotony or as a measure of susceptibility to monotony. He recommends, instead, a consideration of variability in time estimates, citing his observation that low variability appears to be consistently present among those who are accustomed to repetitive work and who seem not to be disturbed by it. Those whose estimates of time show little variation in accuracy or in variability on different types of tasks seem to be least susceptible to the feeling of monotony and most suitable for monotonous work. The attention of such individuals is as completely absorbed by a simple task as by a complex task, by a uniform as by a varied operation. Underestimation of time combined with high variability on highly complicated work, that is on the task assigned in Part 3 of Lossagk's experiment, appears to be an indication of susceptibility to monotony and of unsuitability for monotonous work.

Lossagk describes his findings as suggestive rather than conclusive, but they are particularly suggestive in the light of the unquestioned acceptance, in certain quarters, of overestimation of time as the only direction of change in the estimation of time on monotonous work. The situation appears to be somewhat more complicated than this. The findings of Lossagk seem to be in conformity with the conclusions

[38] S. Wyatt, J. A. Fraser, and F. G. L. Stock, *op. cit.*

of Benussi [84] that the perception of time appears to bear a definite relation to the attention given toward the passage of time. Time intervals appear to be long and are overestimated when the attention of the subject is directed exclusively upon the passage of time, as in the case of the subject whose results are shown in Figure 77G. On the other hand, the passage of time is underestimated when attention is centered not on the interval itself but on other activities occupying the mind of the individual, as in the case of the long and variable intervals of the engineer whose results are shown in Figure 77D. This, for example, explains the apparent slowness of time when one is continually engaged in looking at the clock while waiting to keep an appointment or while waiting for the end of the day's work, in comparison with the more rapid passage when attention is occupied with activities other than the movements of the hands of the clock.

Thompson,[85] in an experiment to be cited in greater detail below, made use of time estimates in determining susceptibility to monotony. He concludes that the experiment shows such estimates to be unreliable as indications of susceptibility to monotony, but fails to provide the substantiating data for this conclusion.

It is clear that the evidence for a change in the estimation of time as a symptom of monotonous work is far from final. At the same time, it is a factor which will bear further investigation. It is probable that *overestimation, underestimation,* and *change in variability* are symptomatic under different conditions which themselves require further analysis. Lossagk's findings that underestimation will occur in the individual who becomes absorbed in other activities when engaged in repetitive work are not in conflict with the conclusion of English investigators that time is overestimated when monotony is experienced inasmuch as such an individual may not experience monotony. Wyatt, Fraser, and Stock [86] have, for example, observed that time appears to pass quickly when the individual engaged in a monotonous task indulges in day-dreaming, and that he does not experience monotony. This may also be true of the apprentices, not accustomed to repetitive work, who become completely absorbed in the complicated task forming the third part of Lossagk's experiment. These findings on time estimation should be considered in relation to differences in susceptibility to monotony to be considered in the chapter which follows.

[84] V. Benussi, *Psychologie der Zeitauffassung,* Heidelberg, 1913, p. 456.
[85] L. A. Thompson, Jr., "Measuring Susceptibility to Monotony," *Pers. J.,* 8 (1929), pp. 172–196.
[86] S. Wyatt, J. A. Fraser, and F. G. L. Stock, *op. cit.,* p. 37.

XXIV. SPECIFIC INFLUENCES IN MONOTONOUS WORK

INDIVIDUAL DIFFERENCES IN SUSCEPTIBILITY TO MONOTONY

1. *The Influence of Intelligence*

The discussion in the preceding chapter on the characteristics of monotony has pointed to the existence of differences among individuals with respect to susceptibility to monotony. Certain individuals become extremely bored, show signs of restlessness and ennui, undergo changes in estimating the passage of time, and assume a lower and more variable rate of production on a task which produces no unfavorable effect on the mental attitude or performance of other workers. So evident is this difference that, at first glance, it would seem possible to agree with Münsterberg that [1] "the feeling of monotony depends much less upon the particular kind of work than upon the special disposition of the individual." Münsterberg reached this conclusion partly as the result of casual observation in industrial plants and partly on the basis of a laboratory experiment involving the perception of differences in the number of related and unrelated words by over 400 college students. Lists of words were presented verbally to the subjects. In each list half the words, or one more, or one less belonged to the same conceptual class, i. e., flowers, birds, etc. The subjects were required to state whether the similar words were more or less numerous than the dissimilar words. To this was coupled a questionnaire on which each subject recorded his own attitude toward uniformity and variety in everyday activities. The results of this and other experiments suggested to Münsterberg that individuals differ in the tendency to inhibit equal or similar impressions.[2] There are those who immediately after receiving an impression are unable to seize the same impression again. There are others for whom, on the contrary, the experience of an impression is a kind of inner preparation for arousing the same or similar impressions. If these two groups have a similar task to perform, in which it is necessary that not a single member of a series of repetitions be overlooked, the two groups react in a very different way. "Those who grasp equal impressions easily and those who are prepared beforehand for every new repetition by their inner dispositions will follow

[1] H. Münsterberg, *Psychology and Industrial Efficiency*, Cambridge, 1913, p. 198.
[2] *Ibid.*, p. 203.

the series without strain and will experience the repetition itself with true satisfaction. On the other hand, those in whom every impression inhibits the readiness to receive a repetition, and whose inner energy for the same experience is exhausted, must feel it as a painful and fatiguing effort if they are obliged to turn their attention to one member after another in a uniform series. This mental torture is evidently the displeasure which such individuals call the dislike of monotony in their work."

The problem of monotonous work in industry, according to this point of view, is reduced to the single problem of developing a series of tests by means of which it can be determined beforehand whether an individual will suffer from monotonous or repetitive work. Such selection, according to Münsterberg, could serve the purpose of procuring fit workmen and effect the complete disappearance of complaints about monotony in industrial work.

Although it may not be possible to agree with this extreme simplification of the problem of monotony, there seems no question that individual difference in susceptibility is a specific factor in the genesis of monotony. The investigation of such differences is a major problem in the psychological study of monotony. Such investigation has first taken the form of an analysis of the relationship between level of intelligence and susceptibility to monotony. Among employment managers and industrial executives there is, in general, more than a suspicion that there exists a direct relationship between general intelligence and monotony. In the opinion of some, the chief problem of modern industry is to find a large enough number of dull and feeble-minded adults to fill the repetitive jobs to which individuals of high intelligence cannot adjust themselves by reason of the boresome simplicity of the task.

According to Pound,[8] for example, "Automatization has now reached a point where individual capacities of workmen count for so little that large employers of labor find less keen minds cheaper than keen minds in many berths, because the less keen mind presents fewer labor complications to the boss, is more easily satisfied, feels labor-strain less, and is less trouble all around. In other words, the intellectual level of labor fixed by the Iron Man is such that a moron trained in habits of doing, regularity, and obedience, is, for many practical purposes, more valuable to his boss for goods-production than one higher in the mental scale. Having brought to the machine less mental luggage of sorts not required by the shop, his adjustment to the present needs of industry is simpler for both parties to the labor-bargain."

The belief that intellectual dullness favors freedom from monotony finds justification in the results of a number of laboratory investigations. So, for example, in a study of department store wrappers and

[8] A. Pound, *The Iron Man in Industry*, Boston, 1922, pp. 182–3.

cashiers, the author [4] found a greater turnover among girls with high intelligence test scores than among those with medium scores. Similar results are reported by Kornhauser [5] who discovered, in a survey of office workers, that labor turnover was greatest among the most intelligent when employed at low grade jobs. Turnover resulted both because such workers became bored and easily dissatisfied with their work and from the fact that it is easier for such girls to procure other jobs.

In a number of English investigations is found further evidence of a relationship between intelligence and boredom in work. Burnett [6] employed four girls working six hours daily in two spells of three hours, four days a week, for a period of two months on the repetitive work of cross stitching. Of the four girls, A and B were very intelligent, C was of average intelligence, D was of low intelligence. Each girl was 17 years of age. The production records of these girls calculated with reference to the production of C, are shown in Table 66. The two most intelligent girls, A and B, although capable of reaching a high output from time to time showed unmistakable signs of boredom in restlessness, yawning, frequent change of position, etc. The rate of production of these girls was more variable than that of the others. The worker who was rated third in intelligence consistently maintained the highest rate of production. In addition, this girl never complained of monotony and seemed generally satisfied with the work. The least intelligent, although not complaining of monotony, appeared to be hampered by clumsiness in doing this work. It is of interest to note

TABLE 66

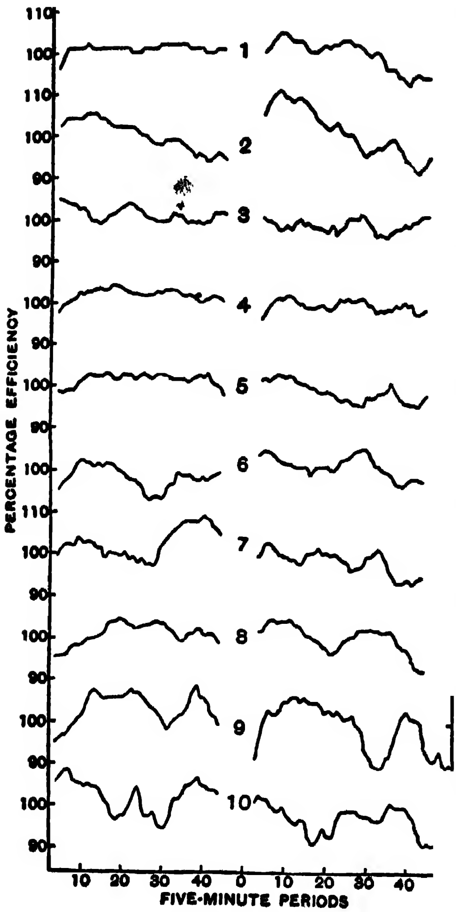
Production on Cross Stitching

SUBJECT	INTELLIGENCE RANK	PRODUCTION RANK	PRODUCTION INDEX
A	1	2	88
B	2	3	84
C	3	1	100
D	4	4	69

(After Burnett)

that the curves of the more intelligent workers showed the drop in the middle spell of work, claimed to be so closely associated with the feeling of boredom in work.

The relation of intelligence and susceptibility to boredom has also



1. Worker G (Chocolate Packing)
Intelligence = 31
Output = + 2.4
Talking = − 12.2
Not boring but tiring about 3:30 P. M.

2. Worker B (Chocolate Packing)
Intelligence = 40
Output = − 32.5
Talking = − 40.5
Very seldom bored except occasionally in the morning.

3. Worker F (Soap Wrapping)
Intelligence = 17
Output = − 18.8
Talking = − 61.2
Work never monotonous.

4. Worker E (Soap Wrapping)
Intelligence = 33
Output = + 9.8
Talking = − 7.0
Sometimes a little bored.

5. Worker B (Soap Wrapping)
Intelligence = 30
Output = − 2.1
Talking = − 40.6
Work very nice and not boring.

6. Worker A (Chocolate Packing)
Intelligence = 131
Output = + 20.0
Talking = − 5.8
Sometimes bored in the morning about the middle of the spell.

7. Worker D (Soap Wrapping)
Intelligence = 118
Output = + 7.9
Talking = + 93.8
Work sometimes very tedious.

8. Worker C (Soap Wrapping)
Intelligence = 110
Output = + 8.3
Talking = + 88.7
Work sometimes monotonous and tiring.

9. Worker E (Inserting)
Intelligence = 128
Output = + 2.9
Talking = + 62.7
Work very monotonous about 11:00 A. M. and 3:00 P. M.

10. Worker H (Winding H)
Intelligence = 137
Output = + 19.2
Talking = + 37.1

FIGURE 78. *Relation of intelligence to boredom. Output of ten workers throughout the day. Curves 1 to 5 show the changes in rate of output of workers of inferior intelligence; 6 to 10, of workers of superior intelligence. Note the greater irregularity in the output curves of the more intelligent workers.*

(After Wyatt, Fraser, and Stock)

been considered in the factory investigation by Wyatt, Fraser, and Stock,[7] to which reference has already been made. The operatives who were the subjects of this study were given a general intelligence examination (Series 33 of the National Institute of Industrial Psychology). The scores obtained by the group ranged from 17 to 142,

with an average score of 70.5. A comparison has been made of production records of workers obtaining intelligence scores above 100 and of those with scores below 50. Results of this comparison are shown in Figure 78. In addition to the composite production curve, the Figure shows:

(a) The output of each operative expressed in the percentage of the average for the group to which the worker belongs;

(b) The extent of talking on the job expressed as a percentage of the group average;

(c) The introspective reports on the feeling of boredom made by the workers.

It is quite evident that the production of workers of inferior intelligence is steadier and less affected by a mid-spell depression than that of the more intelligent workers. Moreover, the introspective reports indicate that while workers of low intelligence appeared to like the repetitive process, those of high intelligence seemed to be quite dissatisfied with the work. The results of this investigation are also significant in showing that although the more intelligent operatives find the job boresome and tedious, their production still remains above average, whereas the production of the less intelligent workers tends to remain below average. This finding helps to emphasize the distinction between efficiency and individual satisfaction on the job which must be considered by the psychologist in the application of his techniques in industry. It points to the importance of considering the possibility of re-adjusting the worker so that there may be more satisfaction on the job for the superior worker, while at the same time his efficiency is kept undisturbed. This problem will be considered in a section which follows, dealing with the effect of the introduction of variety upon the efficiency of workers on a job characterized by uniform or repetitive conditions of work.

2. *The Effect of Individual Differences in Other Mental Traits*

Although intelligence may be effective in determining adjustment in repetitive work it is possible that other mental traits also play a rôle in determining individual susceptibility to monotony. Among the traits which would, on the surface, appear to deserve serious consideration are "attention sets" and the emotional or temperamental characteristics of the individual. The importance of factors other than intelligence has been stressed by Winkler,[8] as a result of a laboratory investigation on repetitive work. The subjects of this investigation included 9 individuals accustomed to monotonous work and 21 not accustomed to repetitive work. Modified cancellation tests and work with the ergograph were employed in the analysis of reaction to re-

[8] H. Winkler, "Die Monotonie der Arbeit," *Schrift. Z, Psy. Berufs*, 19 (1922), pp. 45.

petitive work. Working periods from between 1½ and 8 hours were employed in the course of the examination.

An examination of work curves led Winkler to conclude that monotony is experienced only by those individuals whose attention is neither completely absorbed in a repetitive task nor completely free from it. Such individuals find it necessary to give some but not the whole of their attention to the work. The failure to find purpose in the work, combined with the uniform and tedious nature of the work, stirs up active antipathy to the task expressed by yawning, restlessness, variability in rate of work, etc. In contrast are individuals whose attention is completely absorbed by the repetitive task, who experience pleasure in the continued recurrence of similar impressions. In addition there is a group in whose case the task quickly becomes completely automatized, leaving attention free for other and more interesting pre-occupations. These individuals also fail to experience monotony and may actually find the task pleasant. Winkler found the rate of work to be more uniform when monotony was absent than when a feeling of boredom was experienced in work. Individual differences in susceptibility to monotony are ascribed to differences in "attention set" conditioned by two factors, (a) reaction to similar or homogeneous impressions and (b) the recognition of purpose or aim in the assigned task.

A later experiment by Wunderlich [9] leads to conclusions similar to those of Winkler [10] concerning the incidence and nature of susceptibility to monotony. This investigator undertook to examine under laboratory conditions individual reaction to mechanized work similar to that performed in connection with the operation of an automatic machine. As conditions for the investigation he insisted that the tempo of the work must be set by the machine and not by the operator, that the work must be simple and routine in character, that there must be a certain urge toward production. In addition, he introduced short rest pauses into the work to overcome fatigue. Instead of attempting to duplicate factory conditions, in which the worker is generally employed as a member of a group in a large room, the subjects of the investigation were tested in a small isolated room, free from outside disturbances. However, the noise of the machine and the vibrations provided by it helped to simulate conditions usually present in factory work.

The apparatus used in this investigation is shown in Plate VIII. The major feature of the apparatus is a rotating drum upon which short steel rolls, 4 cm. in length and 1 cm. in breadth, are presented at regular intervals to the subject. The subject is instructed to lift the steel roll and to place it into the opening provided for this pur-

[9] H. Wunderlich, "Die Einwirkung Einförmiger Zwängslaufiger Arbeit auf die Persönlichkeitstruktur," *Schrift. Z. Psy. Berufs,* 31 (1925), pp. 53.

[10] H. Winkler, *op. cit.*

pose. In the instructions the importance of performing this work regularly and without error is stressed. The apparatus is so arranged that the subject cannot dispose of more than one roll at a time, that is, he cannot accumulate steel rolls and dispose a number of them at one time. Failure to place a steel roll in the opening provided for it constitutes a failure.

Facing the subject are a red light and a green light. The subject is told that the green light is a signal that the first of a series of steel rolls is about to appear on the rotating drum. The red light, which appears after 60 of the metal rolls had been handled by the subject, is a signal that a short pause will ensue before the next series of rolls. This short pause, 35 seconds in length, was introduced as a device to overcome to some extent the influence of fatigue. The subject is instructed to use only the right hand in the performance of this work. The performance of the subject is automatically recorded. The apparatus was so arranged that an observer unseen by the subject could observe his responses. At the close of the examination, each subject was asked to reply to a series of questions designed to reveal his subjective reaction to the work.

A careful analysis of test scores leads Wunderlich to conclude that, from the viewpoint of susceptibility to monotony, individuals may be divided into three types.

(1). *Type A* is designated as a "totality type." This represents an individual who has an urge to be completely absorbed in the work which is being done, that is, an urge for a participation of the total personality in the assigned task. His inability to become completely absorbed in this work by reason of its uniformity and limited scope, or because of a tempo imposed from without, produces a blocking, the result of which is a loss of interest in work, and a general feeling of boredom or monotony.

(2). *Type B* is used by Wunderlich to designate the individual who is capable of splitting his attention or "dividing the direction of consciousness" equally between the mechanical operations of the task and an ideational elaboration of it and of related activities. This entails a lowering of intensity of conscious experience, affecting both activities. There is no unpleasant feeling associated with the performance of the task.

(3). *Type C* represents the individual in whose case the task becomes so completely automatized that attention can be fully diverted to other, unrelated mental activities. He concentrates upon ideas which are independent of the work while the work proceeds as a completely mechanized activity divorced from conscious control. The sphere of experience of such an individual has reference essentially to his thought processes, and to the repetitive task itself only in the form of the rhythmic motor tendency which possesses for consciousness the same intensity as that of indirect vision in visual perception. Such an in-

dividual, engaged in "mind-wandering," experiences no feeling of boredom in repetitive work.

It is interesting to note both in this analysis and that of Winkler the reference to the value of "mind-wandering" as a protection against monotony. Lossagk, it will be recalled, refers to this in explaining underestimation of time on the part of intellectually superior subjects when engaged in gazing at a blank wall.

"Mind-wandering (or day-dreaming) appears to compensate for the deficiencies of life in general and industrial conditions in particular. The worker who is able to day-dream becomes oblivious to unpleasant realities and remains comparatively undisturbed by the unsatisfying features of repetitive work.[11] Wyatt, Fraser, and Stock [12] present evidence to show that the amount of boredom felt during repetitive work is inversely related to tendencies of mind-wandering, in the form of curves (Figure 79), obtained in the bicycle chain experiment, illustrating the variations in the rate of working when (a) *the subject experienced boredom* (continuous line); when his thoughts seldom wandered far from the task and the time appeared to pass *unusually slowly,* and (b) boredom was almost entirely absent but mind-wandering very prevalent (broken line). In the former case the rate of working is particularly low about the middle of the experimental period, while in the latter a higher and more uniform rate of working was maintained throughout the day. Boredom is not experienced when the thoughts are entirely detached from the experimental task, and under such conditions, as in Lossagk's experiment, time appears to pass quickly.

Studies by Gemelli and Galli [13] have also revealed differences among workers in an industrial plant with respect to susceptibility to monotony. In this investigation 37 subjects performed the same tests extending over a period of 95 minutes for 20 successive days, (a) under conditions which permitted the worker to control the tempo of the task, and (b) when the supply of material by a moving belt permitted no control of rhythm of work by the worker. The variables of aptitude, of interest, incentive, etc., were controlled to permit direct comparison of the effect of these two conditions upon production. Among other significant findings is a distinct classification of workers into two groups, the *first,* including approximately 70 per cent of the workers, showing higher production and fewer errors when the tempo is imposed from without by the moving belt, the *second,* including the remaining workers, working more efficiently when they control the rate of production. There also appear differences between the two groups in subjective state. The workers who prefer the moving belt seem to

[11] S. Wyatt, "Boredom in Industry," *Pers. J.,* 8 (1929), p. 168.
[12] S. Wyatt, J. A. Fraser, and F. G. L. Stock, *op. cit.,* pp. 36–37.
[13] A. Gemelli and H. Galli, "Sur l'Adaptation de l'Activité Humaine à l'Activité de la Machine," *Rev. de la Sci. du Trav.,* 2 (1930), pp. 1–23.

enjoy the opportunity to think of other interests and the freedom from responsibility for directing the flow of work. Workers in the second group are annoyed by the continual flow of material and enjoy, instead, the opportunity of directing and controlling the rate of work.

An element of novelty is introduced into the explanation of differ-

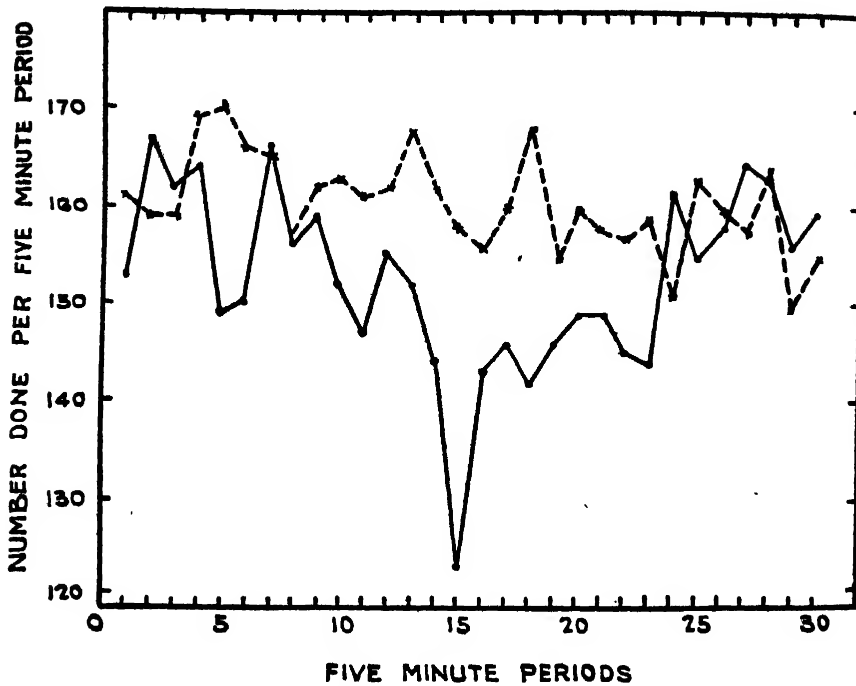


FIGURE 79. *Curves showing rate of working when (a) boredom was prominent and mind wandering almost absent (continuous line) and (b) boredom was slight and mind wandering prominent (broken line).*

(After Wyatt, Fraser, and Stock)

ences in susceptibility by these authors, who find markedly lower and more variable reaction times among those preferring to set their own pace than among those who prefer the moving belt.

For the industrial executive who makes controlled speeds of work and the moving belt the fetich of production, the finding that the majority of factory workers prefer controlled activity must be welcome. It must be recalled, however, that the investigators are dealing with a highly selected, small group of workers engaged for only 95 minutes of 20 working days on this experimental work.

Earlier investigations on susceptibility to monotony have been

critically reviewed by Thompson.[14] This investigator criticizes the use by Wyatt and others of changes in production as a criterion of monotony. He claims that such production curves, even when combined with introspective reports on monotony by laboratory subjects and by operatives, give an inadequate indication of the existence of this state of mind. Following the lead of Münsterburg [15] and of Dunford,[16] Thompson prepared a scaled questionnaire designed to reflect an individual's preference for a uniform or varied existence. The character of the questionnaire is shown in the sample questions below:

1. How often have you moved of your own accord?

Several times yearly	each year or so	few times	never

2. At the present time do you get up at the same hour each morning during the school year?

No, different time each day	yes, when necessary	always

3. When you read or study where do you sit ordinarily?

Same chair in same place	change occasionally	prefer to change often

In addition to self-ratings, each of the 32 subjects included in the study was rated by associates who had known him from one to three years. A combination of self-ratings and ratings by associates gave, according to the author, *a criterion of monotony* with a statistical reliability of approximately .90.

With this criterion of monotony, or of interest in varied as contrasted with uniform activities, were compared *intelligence test* scores, *measures of personality traits* including an emotional history record of the Watson and Chassell [17] type, a *personal history* record with questions similar to those used in the *Woodworth-Wells Psycho-Neurotic Inventory,* and a modification of *Freyd's* [18] *Introvert Extrovert Scale.*

In addition, Thompson made use of four special pieces of apparatus for measuring performance on a very simple uniform phase and a more complex varied phase of the same task. The assumption underlying the use of this apparatus is that if a person is susceptible to monotony this susceptibility will manifest itself most easily and quickly by comparing the error and production records of each subject's performance in the uniform and varied phase of the same general type of work. The four types of work included, (1) *work at a simple punch board;* (2) *work*

at a simple crank; (3) *work at a simple maze;* and (4) *work at number cancellation.* The difference in the simple phase and the complex phase of the work can perhaps be illustrated by reference to the cancellation test. In the uniform phase the subject was required to cancel all 8's; in the varied phase, the subject was required to go through the same list of numbers, cross out 5's and circle 3's, until he came to 7, when he was to circle 5's and cross out 3's until he again came to 7, when he reversed the process, etc. Ten minutes was selected as the period of work with the uniform and with the varied phase of each test, with 5 minute rest periods between work periods.

The degree of susceptibility to monotony on each task was measured by dividing the production record for the first half of the ten-minute work period by the production record for the second half of the work period. This yields a *Production Decrement* ratio for each phase of each kind of work. If the *Production Decrement* ratio of the varied phase is subtracted from the corresponding ratio of the uniform phase, a single score is obtained which expresses the degree of susceptibility to uniformity of the subject for that particular kind of work. A minus score presumably indicates a lack of susceptibility to monotony.

Errors in performance were treated in somewhat the same way, giving a *Percentage Decrement* score, also used to indicate susceptibility on the performances included in the investigation.

An elaborate treatment of results by simple as well as partial and multiple correlation leads the author to conclude that the factors which contribute most heavily to susceptibility to monotony are *emotional instability* and *Production Decrement ratio* of *the punch apparatus.* These are practically of equal importance. Production Decrement ratio on the cancellation test and intelligence also bear some relationship to susceptibility. A battery of four elements consisting of (1) Emotional History Record; (2) Production Decrement difference for the punch; (3) Production Decrement difference for cancellation; and (4) Intelligence, can, according to the author, be used in measuring susceptibility to monotony. As evidence of this he cites a correlation of .71 between these, when optimally weighted, and the *criterion,* that is, the questionnaire on preference for uniform and varied activities to which reference has been made.

The results of the investigation lead the author to conclude that "monotony [19] is an attitude or 'set' which undoubtedly affects one's adjustment to certain types of work. Monotony or uniformity is *not* an attribute of any type of work *per se;* it is a conditioned habit system in the individual, which to a large degree, controls the direction of behavior modification that is possible in that individual." Intelligence, according to the author, plays but a minor rôle in determining susceptibility to monotony, which is as an attitude or "act," reflecting an

[19] L. A. Thompson, *op. cit.*, p. 94.

emotional "set" or "disposition" on the part of the individual toward repetitive work. There are suggestions in the work that susceptibility may differ with respect to particular types of work, but this observation is considered secondary to the establishment of differences in susceptibility, and to the explanation of these differences on the basis of "conditioned visceral habits."

Thompson's study represents a unique and possibly promising technique for future research in the investigation of susceptibility to monotony. At the same time, as is true of other investigations cited above, the conclusions must be accepted with reservations because of the small number of subjects and the very highly selective conditions of the experiment. In addition to these general criticisms, Thompson's conclusions are weakened by a too elaborate treatment of statistical data obtained with relatively few cases.

On the whole, the factory investigations of the type conducted by the Industrial Health Research Board seem to hold forth more promise than the highly specialized type of investigation reported by Wunderlich and Thompson. The observation of objective work records in the form of daily production curves, combined with introspective reports of operatives who have confidence in the observers, would seem to be more valuable for the study of susceptibility to monotony in industrial work than questionnaires on general activities of the type employed by Münsterburg and Thompson. At the same time, in this very complex field of investigation, almost anything in the way of a novel approach is suggestive and helpful, if in no other way than in pointing out additional avenues of research.

It is evident that there is considerable disagreement among investigators with respect to the importance of specific factors underlying susceptibility to monotony. There is no uniform agreement on the nature of susceptibility. There is evidence in widely varied investigations that individual differences in susceptibility to monotony do exist. It is questionable whether such differences can as yet be satisfactorily measured by monotony tests of the type described by Giese [20] and Oberhoff.[21] However, there is no question that the task which awakens monotony in one individual produces no boredom in another. Monotony must then be conceived not solely as a function of the task, but to a large extent as a function of the individual to whom the task is assigned. It is more apt to occur in uniform than in varied tasks, in simple than in complex tasks, in the operation of a machine than in hand work, but, in the final analysis, it is to the susceptibility of the individual, and not to the task, that the responsibility for the feeling of boredom must in large part be ascribed.

[20] F. Giese, *Psychotechnik*, Breslau, 1928, p. 132.

[21] E. Oberhoff, "Analyse der Fördermaschinistentätigkeit und psychologische Begutachtung von Fördermaschinisten," *Ind. Phychot.*, 7 (1930), 73–90.

THE EFFECTS OF CONDITIONS OF WORK UPON MONOTONY

1. *The Effect of Uniformity and Variety in Work*

Uniformity in work is a prevailing feature in the monotony producing situation. The insistence upon uniformity, upon specialization, is based upon the belief that keeping the worker at one task favors production, whereas, variation of any kind in the performance of a task interferes with industrial proficiency. As a matter of fact, the concern of the psychologist and economist with the effects of repetitive work upon the worker has been looked upon as of only academic interest by industrial leaders, who insist that the highly repetitive process is necessary to maintain the demand quantity production, and who are convinced that the efficiency of the individual worker is directly proportionate to the degree of automatization of his work. The industrial executive is inclined to believe that any procedure which substitutes variety for uniformity can do nothing but interfere with the productive efficiency of his plant. He may even frankly state that his responsibility to the worker is a limited one, and that the worker can seek employment elsewhere if he fails to find happiness or becomes irritated or over-fatigued in the specialized job on which he is engaged. He may even fall back on the questionable discovery of Goddard, so widely held by the intelligenzia who read the *American Mercury,* that the average American is a moron, and does not deserve a better fate than to act as a substitute for a robot in the American plant.

The influence on production of uniformity and variety of work has been investigated in a number of laboratory and plant studies. One of these, by Wyatt,[22] was carried out in connection with the packing of drugs in the shipping room of a manufacturing concern. Three schedules of work were followed. In one, the drugs were assembled, counted, packed, and wrapped by each worker. The second involved a change in occupation every half hour. In the third schedule of work the same work was done throughout the day. A schedule involving half-hour changes was found to be least efficient. On the other hand, there was found little difference in efficiency between the work involving few variations and work involving strict uniformity. Moreover, observations on the part of the investigator and introspective reports led to the conclusion that repetitive work throughout the day was conducive to fatigue, boredom, and monotony.

In a more recent study, Wyatt and Fraser [23] analyze the effects of variety as compared with uniformity of work in soap wrapping, handkerchief folding, cigarette making, cartridge case assembly, and in

[22] S. Wyatt, "The Effect of Changes in Activity," *Ind. Fat. Res. Bd. Rep.*, No. 26 (1924), pp. 13–37.

[23] S. Wyatt and J. A. Fraser, "The Comparative Effects of Variety and Uniformity in Work," *Ind. Fat. Res. Bd. Rep.*, No. 52 (1928), pp. 36.

bicycle chain assembly. In the *varied phase* of *soap wrapping*, for example, the operatives first went to the storeroom and obtained 144 tablets of soap and the same number of wrappers. 72 of these were wrapped in wax paper and in an outer wrapper, the ends of the wrappers gummed and labeled and the completed tablets packed in the small cardboard boxes. The worker then changed from a sitting to standing position and wrapped the filled boxes (4 boxes to each package) in brown paper, sealed and labeled the ends and placed them in a wooden case. The remaining 72 tablets were then treated in a similar manner and the wooden cases carried to a conveyor at some distance away. In the *uniform phase* of this work the operatives were placed at a bench to which soap was supplied by a conveyor. The responsibility of the girl was limited to wrapping the soap and packing the tablets in the card-board boxes.

Observations were made on 6 girls employed for 5 days in both the varied and uniform phases of operation. Results obtained under both conditions of work are shown in Table 67. It is evident that the uniform method of work favors production. However, the difference between production under the two conditions of work is not great. In addition, an analysis of work curves showed that the uniform rate of working was associated with greater variety in rate of production from period to period.

TABLE 67

Average Hourly Output on Days of Uniform and Varied Activity

SOAP WRAPPING

WORKER	A	B	C	D	E	F
Uniform process ...	194.2	246.0	243.8	223.6	245.5	214.3
Varied process	185.7	240.9	237.3	222.5	230.2	206.9
Per cent diff.[24]	—4.4	—2.1	—2.7	—0.5	—6.2	—3.5

In the case of *handkerchief folding* two different styles, known respectively as the Oblong and French style, were employed. Eight girls were observed for a period of 3 weeks, and the time taken to fold a dozen handkerchiefs noted continuously throughout the spell. On some days the two styles were used alternately, the style being changed at hourly intervals. On other days, the same style of folding was maintained throughout the day. Production under uniform and varied conditions of work are shown in Table 68. In the case of this task variety slightly favors efficiency.

In the case of *bicycle chain assembly* (Table 69) the differences are found to be more markedly in favor of variety. Moreover, an analysis

[24] Per cent difference in output is calculated on the basis of output observed in the uniform phase of work. (After Wyatt and Fraser.)

of work curves shows that when the same kind of activity was continued throughout the day, there appears a pronounced decrease in efficiency toward the end of the working spell. This decrease is less marked when operatives are employed on a different task in the first half of the spell.

In the case of *tobacco weighing* and *cigarette making* an attempt was made to determine:

(1) *The optimum duration of one form of activity before changing to another.*

(2) *The most suitable type of work for the alternate process.*

The character of the procedure employed in this phase of the study may be illustrated by reference to cigarette making. On this job each

TABLE 68

Average Hourly Output (in dozens) on Days of Uniform and Varied Activity

HANDKERCHIEF FOLDING

WORKER	A	B	C	D	E	F	G	H
Uniform process .	27.8	27.5	24.1	26.3	24.9	27.1	22.8	24.6
Varied Process ...	27.9	28.0	24.8	26.4	24.5	26.9	23.7	24.9
Per cent diff.[25]...	+ .4	+ 1.8	+ 2.9	+ .4	— 1.6	— .7	+ 3.9	+ 1.2

worker is supplied with tobacco from which a small quantity is taken and rolled prior to insertion in cylindrical cigarette paper. The protruding ends of the tobacco are then cut off with a pair of scissors. Before the experiment was introduced, the ends of the cigarettes were cut off by assistants, but for the purpose of this experiment both operations were performed by a single operative.

Operatives were paid on a piece-rate basis. Hours of work were from 8.00 to 12.30 and 1.30 to 5.00 with a fifteen minute break in the early part of the morning.

The schedule of work followed in the course of the experiment was as follows:

Monday: Making and cutting alternately according to the worker's inclination. (Series 1)
Tuesday: Making for one hour, then cutting. (Series 2)
Wednesday: Making for 1½ hours, then cutting. (Series 3)
Thursday: Making for three hours, then cutting. (Series 4)
Friday: Making all day. (Series 5)

Each of ten workers was observed for a period of approximately 2 weeks in the course of the ten-week period over which this experiment extended.

[25] Per cent difference in output is calculated on the basis of output observed in the uniform phase of work. (After Wyatt and Fraser.)

A record was kept of the number of cigarettes made in consecutive 5-minute periods and the nature, duration, and time of all voluntary pauses were noted.

The variations in rate of production coinciding with these different conditions of working are shown in Figure 80. Each curve indicates

TABLE 69

Average Hourly Efficiency at Corresponding Times on Days of Uniform and Varied Activity

BICYCLE-CHAIN ASSEMBLY

WORKER	A	B	C	D
Uniform process	77.4	61.4	61.5	62.8
Varied process	79.4	64.2	64.6	64.3
Per cent diff.[26]	+ 2.6	+ 4.6	+ 5.0	+ 2.4

the output produced in consecutive five-minute periods throughout the day, expressed as a percentage of the average output on the days of continuous, unvaried activity. The drops in the curves in the early part of the morning spells are caused by operatives stopping for refreshments at slightly different times on different days.

The curve obtained on days of uniform activity is both lower and of a different shape than those obtained under more varied conditions of work. It is also characterized by the noticeable depression in the middle of both the morning and afternoon spell of work which has been so often observed in uniform work accompanied by monotony.

When the form of work is changed after three hours of uniform activity, a somewhat different type of output curve is obtained. In the first place, production following the luncheon interval is higher and free from the marked depression observed on the days of uniform activity. Otherwise the afternoon curve is similar in tendency to the one previously described, but is on a higher level and has a more pronounced final spurt.

When the activity is changed at the end of 1½ hours, the beneficial effects are still more marked. The output in the latter half of the morning spell is the highest recorded in any of the experimental series. It is also high in the initial and final stages of the afternoon spell. Although in the latter spell there is a reduction in output in the middle period, the extent of the decrease is very much less than under the more uniform conditions of work. Somewhat similar tendencies are present when the same form of activity continued for only one hour. Under such conditions the output curve approaches more closely to a horizontal straight line.

[26] Per cent difference in output is calculated on the basis of output observed in the uniform phase of work. (After Wyatt and Fraser.)

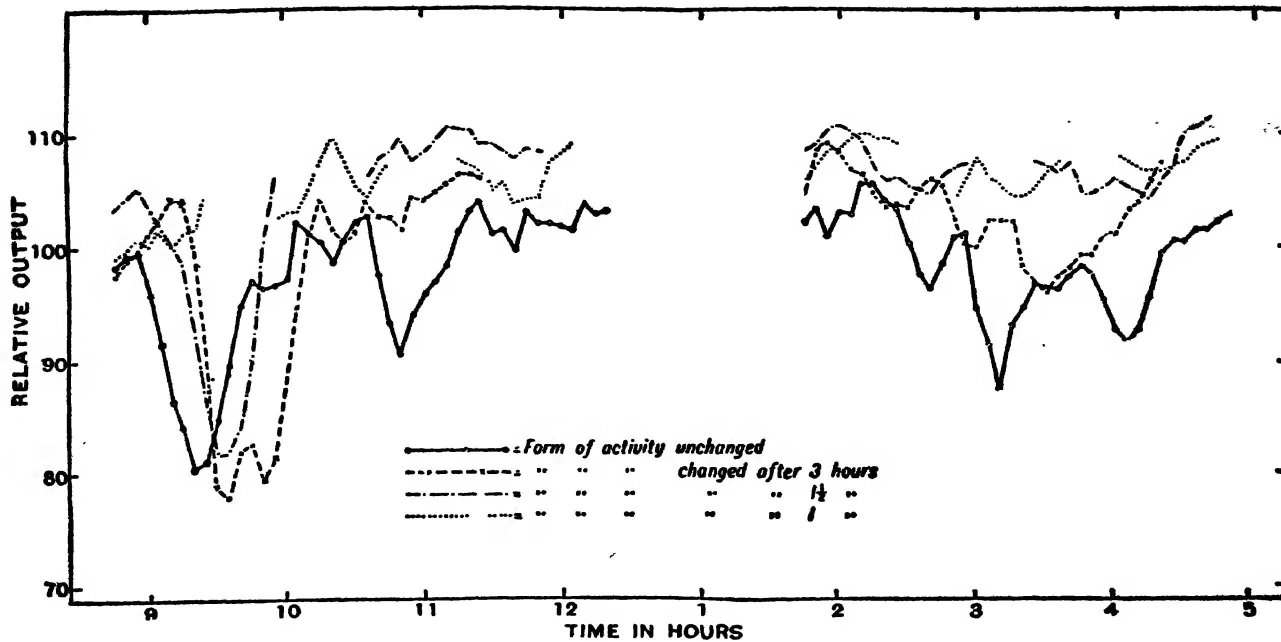


Figure 80. *Variations in the rate of working produced when the form of activity is changed at different times within the spell of work (Cigarette making).*

(After Wyatt and Fraser)

"The results of this investigation favor the view that *complete uniformity in manual repetitive work is generally less productive and leads to greater irregularity in the rate of working than a reasonable degree of variety,*[27] which is also preferred by the workers, though this effect seems to depend partly on the nature of the process and partly on the individual operative. Furthermore, while frequent changes are definitely detrimental to production, there is some evidence that the best conditions are attained when the form of activity is changed after 1½ to 2 hours of unvaried work."

Wyatt and Fraser [28] accept the hypothesis, in explanation of the increased efficiency with variability in work, that fatigue produced by light repetitive work is more local than general. This is in accord with what has been generally observed in the case of uni-lateral muscular activity. A change in the form of activity serves to utilize other parts of the body mechanism, thereby creating a situation which is favorable to productive activity. In so far as this is the case, changes in work should be so arranged as to balance the use of the muscles—or, if possible, to alternate the fatiguing muscular process with one which is essentially mental in character. A high degree of resemblance between alternating forms of activity, although subjectively satisfying, is not conducive to increased output. These viewpoints are in accord with earlier laboratory studies on the more general aspects of uniform and repetitive work.[29]

The results and conclusions of this investigation have been cited in some detail by reason of the unique character of its approach and because of the significance of its findings. The conclusions may not apply directly to other forms of work, inasmuch as the benefits to be derived from an increase in the variety of activities depend upon:

(a) The type of work,
(b) The nature of the alternating activities,
(c) The frequency of the change.

However, the demonstration, under controlled conditions, that the substitution of variety for uniformity in simple tasks may actually increase productive efficiency is of tremendous importance. Its significance is increased when it is recalled that variation is in most instances followed by increased satisfaction on the part of the worker, in the case of whom "the anticipated change in work seems to create a more buoyant attitude toward the task and diminishes the inhibitory

[27] S. Wyatt and J. A. Fraser, *op. cit.*, p. III.
[28] *Ibid.*
[29] A. Weygandt, "Über den Einfluss des Arbeitswechsels auf fortläufende geistige Arbeit." *Psychol. Arbeit.*, Vol. II, pp. 118–202.
E. L. Thorndike: "Educational Psychology," Teachers College, Columbia Univ., 1914, Vol. III, p. 135.

effects produced by the prospect of an unbroken spell of uniform work."[30]

To the extent that variety improves working efficiency and mental attitudes it becomes possible for industry to promote the increased output and improved adjustment of workers susceptible to monotony, at no economic loss, merely by a re-organization of the conditions of work. Such re-organization would unquestionably entail serious administrative difficulties in many plants. The administrative problems *may,* however, in many instances be less serious, both to the individual plant and to society, than the decreased production, the lowered morale, the unrest, and impaired social adaptation *apparently* noticed when individuals who are susceptible to monotony are forced to labor at monotony producing tasks.

2. *The Influence of Other Conditions of Work*

(a) *Rest Pauses.* An analysis of the production curve in repetitive work has revealed a tendency for a decrease in the rate of production co-incident with the onset of monotony. Studies[31] conducted by the Industrial Fatigue Research Board have indicated that properly spaced *rest pauses* tend to delay the onset of boredom and to maintain the uniformity of output at the level of the early part of the work spell.

The value of the rest pause in reducing monotony has been confirmed through an investigation in a textile plant by Mayo.[32] In the spinning department of this plant turnover was found to be 250 per cent. In addition, there was much complaint about health by the workers and considerable pessimistic revery associated, according to Mayo, with monotony. The introduction of rest pauses, during which workers were instructed to lie down and relax, resulted in increased production, a decrease in fatigue, and a virtual disappearance of pessimistic reveries. Turnover was almost completely eliminated. In this investigation the variables of fatigue, morale, and monotony have not perhaps been so completely isolated as in the English studies, but monotony seems to be unquestionably one of the variables involved. According to Wyatt[33] "there is not the least doubt that a rest of ten minutes' duration, introduced about the middle of the work-spell, tends to neutralize the unpleasant and unfavorable effects of repeated activity, and is capable of producing an increase in output varying from 2 to 10 per cent."

(b) *System of Payment.* There is evidence that the method of pay-

[30] S. Wyatt and J. A. Fraser, *op. cit.*, p. 24.

[31] *a.* H. M. Vernon, T. Bedford and S. Wyatt, "Two Studies on Rest Pauses in Industry," *Ind. Fat. Res. Bd. Rep.*, No. 25 (1924), pp. 34.

b. S. Wyatt, "Studies in Repetitive Work," *Ind. Fat. Res. Bd. Rep.*, No. 32 (1925), pp. 43.

c. H. M. Vernon and T. Bedford, "Rest Pauses in Heavy and Moderately Heavy Industrial Work," *Ind. Fat. Res. Bd. Rep.*, No. 41 (1927), pp. 34.

d. S. Wyatt, "Rest Pauses in Industry," *Ind. Fat. Res. Bd. Rep.*, No. 42 (1927), pp. 24.

[32] E. Mayo, "Day-Dreaming and Output in a Spinning Mill," *J. Nat'l Inst. Ind. Psych.*, *2* (1925), pp. 203–209.

[33] S. Wyatt, "Boredom in Industry," *J. Pers. Res.*, 8 (1929), pp. 161–171.

ment affects the appearance of monotony. Sachs [84] early expressed the view that monotony may be more easily induced under a time-rate than under a piece-rate system of payment. Evidence of this is reported by Wyatt, Fraser, and Stock [85] in the form of expressions of preference by packers in a chocolate factory. Added interest and satisfaction seem to be obtained from a direct comparison of production with the objective results in the form of money payment. Attention otherwise centered only on the slow passage of time becomes directed toward this other aspect of the job.

(c) *Changes in Operating Methods*. An experiment in the manufacture of cigarette tins [86] serves to illustrate the possible effect of slight changes in operating methods, not hitherto discussed, upon the incidence of monotony. On this task, 3 girls worked in a row on a moving belt placing air tight lids on cigarette tins. The flow of work was such that the girl in position 1 actually handled approximately twice as many tins as the girl in position 3. To compensate for these differences it was customary for the girls to change positions at the beginning of each day's work. The introduction of 6 changes in position per day resulted in an increase of production of approximately 10 per cent, in an increase in the uniformity of rate of production (closer approximation of the typical production curve), and to a decrease in monotony. Similar results have been obtained by the author in an analysis of the production of female wool sorters.

The method of supplying material to the workers also affects boredom. The division of a batch of work into smaller units appears to favor the maintenance of interest and the delay in the onset of monotony. According to Wyatt and Fraser [87] the unending flow of material on a moving belt gives the impression of an endless task. When material is supplied at intervals throughout the period of work, each unit is regarded as a self-contained whole. In the completion of each unit the worker finds the same satisfaction and stimulation which appear only at the end of the morning's work and of the afternoon's work when the operative is furnished with a single or continuous supply for the entire spell. However, differences in preference for the "controlled" and "uncontrolled" tempo, such as noted by Gemelli and Galli [88] must be considered in this connection.

(d) *Other Factors*. The opportunity for workers to *engage in conversation* has been suggested as an antidote for monotony. The effect of talking has been observed in both the laboratory and industrial studies by Wyatt, Fraser, and Stock.[89] The percentage increase in time taken to complete a unit when activities were accompanied by talking

[84] H. Sachs, "Das Monotonie problem," *Z. fur Ang. Psych.*, 16 (1920).
[85] S. Wyatt, J. A. Fraser and F. G. L. Stock, *op. cit.*, p. 34.
[86] S. Wyatt and J. A. Fraser, *op. cit.*, Appendix A.
[87] *Ibid.*, p. 29.
[88] A. Gemelli and A. Galli, *op. cit.*
[89] S. Wyatt, J. A. Fraser and F. G. L. Stock, *op. cit.*, pp. 22–29.

was obtained by averaging all the observations recorded when conversations occurred and comparing them with the average of the silent period. The results show that talking affects output adversely. The extent to which talking affects production seems to be related to the industrial activity involved. However, introspective reports suggest that it is a powerful antidote to boredom. In view of this, it is possibly a method to be employed to overcome monotony, in spite of its effect upon production.

The maintenance of interest by the dissemination of more detailed knowledge about the job has been suggested as another method of overcoming monotony. This represents an indirect way of injecting into the task an interest not inherent in the uniform operation itself.

The development of group loyalties, of an active participation in the maintenance of standards, representation in management, etc., have likewise been recommended as substitutes for creative experiences not present in specialized tasks. However, the influence of these more general devices is still a matter of conjecture, awaiting the controlled analysis to which the factors discussed above have already, to some extent at least, been submitted.

SUMMARY

This review of findings and viewpoints in the study of monotony reveals an approach from two angles, viz.:

(1) *An analysis of the nature of monotony.*

(2) *An experimental study of specific influences.*

The former approach has resulted in the formulation of a number of theories with respect to the causes of monotony. The foremost of these may be briefly summarized:

(a) Münsterburg,[40] following a viewpoint expressed earlier by Ranschburg,[41] refers monotony to difficulty in the perception of repeated similar or homogenous stimuli. Individuals whose perception of a stimulus is facilitated by others, similar to it, which have preceded it, do not experience monotony in repetitive work. Those who are compelled to attend to each successive uniform stimulus only with effort, because the reception of each impression inhibits the reaction to the next similar impression in a series, experience a feeling of displeasure or monotony.

(b) If the viewpoint of Veblen,[42] or Parker,[43] is to be accepted, monotony is largely tension resulting from the conflict between native

[40] H. Münsterburg, *op. cit.*

[41] P. Ranschburg, "Über Hemmung gleichartiger Reizwirkungen," *Zeit. Psych. und Phys. & Sinn,* 30 (1902); "Über die Bedeutung der Ahnlichkeit beim Erlernen, Behalten und bei der Reproduktion," *J. Psych. und Neur.,* 5 (1905).

[42] T. Veblen, *op. cit.*

[43] C. Parker, *op. cit.*

urges toward adaptive response patterns, or *instincts*, and the highly specialized and repetitive tasks of modern industry.

(c) An inhibitory theory of boredom is favored by Myers [44] as a result of the study of simple muscular activities. Ergographic experiments have shown that in long continued simple muscular work, through the control of the spinal cord, local inhibitory processes are set up which prevent the evil effects of excessive monotonous *muscular* excitation. According to Myers, in monotonous mental work a somewhat similar local function can be observed. If work must be continued, "the constant effort of the self to overcome these intruding inhibitions of local muscular or mental monotony is usually accompanied by feelings of 'boredom' as interest—i. e., the pleasurable incentive in the work—wanes, and later by feelings of 'weariness' as that effort is invoked with greater difficulty. The feeling of monotony, resulting from the conflict developed in overcoming inhibitory forces, is thus a warning against the continuance of the occupation." [45]

Myers points out that [46] in many industrial processes a special "attitude" or "set" must always be maintained. This is impaired by monotonous work. Boredom is the unpleasant feeling experienced in the process of struggling against incompatible tendencies in preserving the requisite "attitude" or "set" and arises whenever it is necessary to continue activity in the face of intruding desires and inclinations.

"This view of boredom seems to be particularly applicable to repetitive processes in industry, in which there is usually little inherent interest, for unless perfect mechanization of an operation is achieved, diverted attention may be prejudicial to the worker or her machine. Natural tendencies, therefore, are constantly being restrained in order that production may proceed." [47]

(d) Similar to this viewpoint is the theory developed by Winkler,[48] Wunderlich,[49] and Thompson [50] that boredom is allied to the "attention set" of the individual. According to these investigators boredom is associated with a conflict between the urge for attention to become wholly identified with the activity, and an incapacity to balance this urge with conditions of operation and a tempo imposed from without. The individual whose attention becomes either entirely absorbed in the task or entirely disassociated as a result of its mechanization, is free from the feeling of boredom in work.

"The competition for attention which occurs under ordinary circumstances is between what one wants to attend to and what he needs to attend to. The wants must be inhibited in favor of the needs. To

[44] C. S. Myers, *Mind and Work*, London, 1920, pp. 204.
[45] *Ibid*., pp. 48–49.
[46] Ibid., p. 52.
[47] S. Wyatt, J. A. Fraser and F. G. L. Stock, *op. cit*., p. 4.
[48] H. Winkler, *op. cit*.
[49] H. Wunderlich, *op. cit*.
[50] L. A. Thompson, Jr., *op. cit*.

maintain attention upon a routine task when the mind is drawn toward pleasing objects, memories, and imaginations means the expenditure of effort and is fatiguing. When the need is great, as in tending a rapidly revolving and dangerous machine so that fluctuations of attention might mean an accident, the inhibition of the distractions soon becomes wearisome. The task has become monotonous." [51]

The experimental approach to the study of monotony has resulted in certain definite conclusions of immediate significance to industry and has pointed to profitable fields for further investigation.

(a) Monotony is shown to be distinct from fatigue. It is a loss of interest, a disinclination to work which may appear early in the spell of work and disappear toward the end of the spell when fatigue should be at its height. It is a mental state, apart from fatigue, which calls for greater effort in the completion of the task and in repressing ideas and desires in conflict with this need.

(b) There are individual differences in susceptibility to monotony. These appear to depend partly upon intelligence, partly upon temperament, and probably involve a "total personality set." One of the most effective procedures in decreasing monotony in industry is the selection for repetitive jobs of those least susceptible to monotony.

This finding has a definite bearing on the problem of conflict between the creative impulse and repetitive work. It is evident that there is no *universal* desire for self-expression in the work itself. There are many who find routine work desirable, who like tasks that can be performed with the worker almost asleep, or that leave the mind free for other pleasurable activities. There are others, apparently a smaller number, who rebel against uniform, specialized work, but even in the case of these, adaptation is not so difficult as is suggested by the protagonists of the "creative" instinct.

(c) The introduction of variety into work reduces the feeling of boredom without interfering with productive efficiency in many kinds of work. As a matter of fact, production may actually be increased. This finding suggests the possibility of overcoming such unsatisfactory individual and social effects as may be produced by repetitive work by a simple administrative re-adjustment of conditions of working.

(d) The feeling of boredom can be reduced, even in the case of those susceptible to monotony, by adjusting the conditions of work, e. g., by substituting piece-rate for time-rate payment, by allowing conversation, by creating indirect interest in the task, by dividing the task into self-contained units, etc.

(e) Experimental investigations indicate clearly that monotony promotes individual maladjustment in many instances. There is some evidence that group unrest may be favored by pessimistic and irrational revery associated with boredom in work. There is no direct evidence

of a serious conflict between instinctive tendencies toward creation, workmanship, self-assertion, etc. and the repetitive tasks of modern industry. The viewpoint that the human mind is dulled, and broadened social participation hindered by repetitive work, remains unconfirmed by experimental investigation. These remain spheres of investigation which are almost untouched, offering almost limitless opportunity for much discovery, perhaps not altogether in confirmation of the viewpoint, through the application of techniques in process of development by investigators in the field of social psychology.

XXV. MOTIVES IN INDUSTRY

HARMONY?[1]

I am working with the feeling
That the company is stealing
Fifty pennies from my pocket every day;
But for every single pennie
They will lose ten times as many
By the speed that I'm producing, I dare say.
For it makes me so disgusted
That my speed shall be adjusted
So that nevermore my brow will drip with sweat;
When they're in an awful hurry
Someone else can rush and worry
Till an increase in my wages do I get.

No malicious thoughts I harbor
For the butcher or the barber
Who get eighty cents an hour from the start.
Nearly three years I've been working
Like a fool, but now I'm shirking—
When I get what's fair, I'll always do my part.
Someone else can run their races
Till I'm on an equal basis
With the ones who learned the trade by mining coal.
Though I can do the work, it's funny
New Men can get the money
And I cannot get the same to save my soul.

(The above poem was composed by a machine-shop worker out of the fullness of his heart. It was discovered on the bulletin board of the shop in which he worked.)

Why man works is a fundamental question in considering man's efficiency and adjustment in industry. Categorical answers to this question are not difficult to find. He works, according to the moralists, because of an inner urge that compels him to contribute his share as a member of a working society of men. Man works, says the realist, be-

[1] From S. B. Mathewson, *Restriction of Output Among Unorganized Workers*, New York, 1931, p. 127.

cause only by doing so can he feed himself and his family and provide for other wants. According to this view he works, because he is paid for it, and the amount of work he will do and the satisfaction he derives from it, will depend upon the amount of pay he receives, in other words, upon the attractiveness of the *financial incentive.*

TYPES OF FINANCIAL INCENTIVES

An emphasis upon wages as an incentive to work is evident in the system of scientific management conceived by Taylor and extended by his followers. As has already been pointed out in Chapter II, Taylor recognized the existence of other incentives, but, in practice, increased pay for increased work was employed as the sole inducement for encouraging maximum production.[2] The importance attached to wages is evident in the *differential system of wage payment,*[3] devised by Taylor, in which each operation is assigned two piece prices, one from 30 per cent to 50 per cent higher than the other. The worker who completes in a day a number of pieces less than the standard task, as established by time studies, is paid at the lower rate. The worker who completes more than the number of pieces included in the standard task is paid at the higher rate. Taylor's system has been elaborated into the *Merrick Multiple Piece Rate* system, with 3 distinct piece prices—a lower one for production up to 83 per cent of the standard task, a middle one applying to production between 83 per cent and 100 per cent, and a higher piece price paid for production above 100 per cent of the task.

To avoid the penalty imposed upon new workers by these plans, a *task and bonus rate* has been developed. In this each worker is paid an hourly rate if his production falls below the standard, and at a piece rate if production equals or exceeds the standard task. The *piece and bonus plan* represents a further development of this system. Under this plan each job is assigned a piece price. A standard task is established on the basis of average rate of production per piece for a period of several months. The incentive for increased production is in the form of a bonus, amounting generally to approximately 20 per cent of the normal piece-work earnings, for each worker who exceeds the task level.

Other wage incentive plans have been used.[4] They all have one feature in common—an attempt to increase the amount of production, and thereby lower the unit cost of production, by employing the lure of increased earnings. There is no question that such financial incentive plans have served the purpose of raising output. So, for example, a

recent study of the operation of more than 20 super-incentive wage plans shows that:

1. Production levels have generally increased from 1 per cent to 18 per cent by the use of such plans;
2. Employees' average earnings have generally increased from 1 per cent to 30 per cent; and
3. Total costs per piece have generally decreased from 1 per cent to 11 per cent.[5]

THE INADEQUACY OF FINANCIAL INCENTIVES

In spite of these elaborate techniques for stimulating the worker to increased production there is evidence that industry is far from attaining the objective of maximum output. There appears still to be a large reserve of yield resulting in part from the voluntary restriction of output by the worker—a "conscientious withdrawal of efficiency" by slowing down, bungling, and obstruction.[6]

For many years unions have established a frank policy of controlling output in order to increase their power; to stretch out available work; to avoid reduction in piece rates, and to protect the worker from an undue expenditure of energy. Such restriction is well exemplified in the limitation of the number of bricks by the bricklayers' union; in the refusal of painters' unions to allow the use of a brush wider than 4½ inches; in the demand by plumbers' unions that pipe be cut and threaded on the job, etc.[7] Voluntary limitation of output is not, however, limited to organized workers. As Mathewson [8] has recently shown, it is being practiced on an enormous scale by factory and office workers at diverse occupational levels in practically every industry. Evidence of this was obtained by means of first hand observations and from interviews with approximately 350 workers and 65 executives. While making observations the investigator actually worked as a laborer, machine operator, and in other occupations, living with working people in their home environment. Interviews included formal conferences with people who had been informed of the purpose of the inquiry and informal conversations with fellow-workers. Whenever possible, two or more workers employed under the same conditions were interviewed in order to check the accuracy of statements. In addition to observations made by the investigator himself, a group of 6 workers cooperating in the study made a series of separate reports in the form of personal letters from industrial centers.

Two hundred and twenty-three instances of obvious restriction were recorded in detail. These were found in 105 establishments in 47 locali-

ties, representing 25 classified industries and 14 miscellaneous industries. Cases included two types, (a) those in which production was actually reduced, and (b) those in which the intent to restrict was clearly evident, whether or not restriction actually resulted.[9]

The nature of restriction and the character of the underlying factors are well illustrated by data gathered in a machine manufacturing plant, where the investigator was one of a gang of 3 production workers, on a group bonus, who believed that if earnings rose above 95 cents an hour, the management would reduce rates. Although the men could easily have produced approximately twice as much work, output was intentionally restricted to the lower figure to prevent cuts. This is an instance of the many cases in which the worker finds justification for limitation of output in the administration of the very plan—the wage-incentive plan—which is intended to augment production.[10] Associated with this is limitation of output as an expression of resentment against speeding up, as evidenced, for example, in the custom of workers on a conveyor line in a can manufacturing plant to throw a piece of scrap tin into the works, or to put a can in crookedly, in order to stop the belt after it had been speeded-up 33⅓ per cent by a "cheese engineer."[11]

Production is adjusted by the worker not only with respect to pay and speed of work but as a means of postponing lay-offs, steadying employment, and stabilizing earnings.[12] In addition, such intrinsic factors as grievances, dislike, hard feelings toward management, and

discouragement unquestionably interfere with maximum production. There may be no justification for the grievance, and antipathies, but these, whether imagined or real, have an unquestioned effect upon the amount of work which is turned out.[13] Dislike of over-time work and the monotony of the operation also drive workers to seek relief in restrictive practices.[14] To these causes, which are justified by the worker, and which may be perhaps justified by others, is that limitation of output which results from a straightforward disinclination to work and which, in some cases, at least, explains slowing down and perhaps actual sabotage on the part of the worker.

As a result of observations and interviews with workers and managers, Mathewson reaches the conclusions that:

"1. Restriction is a widespread institution, deeply intrenched in the working habits of American laboring people.

2. Scientific management has failed to develop that spirit of confidence between the parties to labor contracts which has been so potent in developing good-will between the parties to a sales contract.

3. Underwork and restriction are greater problems than over-speeding and over-work. The efforts of managers to speed up working people have been offset by the ingenuity of the workers in developing restrictive practices.

4. Managers have been so content with the over-all results of man-hour output that only superficial attention has been given to the workers' contribution or lack of contribution to the increased yield. Attempts to secure increased output have been marked by traditional and unscientific methods, while the workers have held to the time-honored practices of self-protection which antedate time study, bonus plans, and other devices to encourage capacity production.

5. The practices of most manufacturing managements have not as yet brought the worker to feel that he can freely give his best efforts without incurring penalities in place of the rewards which usually accompany special attention to duty in other fields of endeavor. Regardless of how much the individual may or may not desire to contribute a full day's work, his actual experiences often turn him away from good working habits."[15]

THE QUEST FOR NON-FINANCIAL MOTIVES-IN-WORK

This analysis of restriction of output reveals not only an unhealthy economic condition, but a serious situation in workers' attitudes toward management. It is one sign of a defeatist morale which influences tremendously both the economic efficiency of industry at large and the adjustment of the worker in the individual plant. Other signs of waste

[13] *Ibid.*, p. 103.
[14] *Ibid.*, p. 152.
[15] *Ibid.*, pp. 146–47.

in human values, growing out of unfavorable attitudes and dissatisfaction in work, are evident. Among these is the strike, which is perhaps the most evident expression of industrial discontent. For the 25 years between 1881 and 1906 there was recorded in the United States an average of 1470 strikes yearly. For the 5 year period subsequent to 1917 an annual average of 3342 strikes—10 per day—provides one measure of the destructive force—in time, money, production, and individual suffering—of industrial dissatisfaction.[16]

Such facts have focussed attention on the need for a more detailed analysis of *motives-in-work* to determine the factors that underlie attitudes and activities which promote or interfere with economic efficiency and individual satisfaction at work. As never before, in industry, there is an appreciation of the vastness of human powers and of the delicacy of their control. As never before, there is a search for the springs of action—for a better understanding of the deeper sources of men's daily doings at work.[17]

THE INSTINCTIVE BASIS OF ECONOMIC ACTIVITY

In the search for those deeper sources certain psychologists, economists, and sociologists—among them Patten,[18] Veblen,[19] Trotter,[20] Tead[21]—have pounced upon the "instinct" as the prime mover in economic activity. This emphasis on the instinctive, and therefore impulsive basis of human conduct, reflects a reaction against older interpretations that viewed behavior as almost wholly rational and willful.[22] It represents a departure from a *hedonistic* theory of action which explains all conduct as motivated by a desire to secure pleasure and to avoid pain.[23] It discards the concepts of specific "conscious" and "unconscious desires" as the springs of action, and substitutes an impulsive force of some instinct as the driving power behind every activity. This viewpoint accepts as a fundamental assumption McDougall's statement that "the instinctive impulses determine the ends of all activities and supply the driving power by which all mental activities are sustained," and that "without them the human organism would become incapable of activity of any kind; it would be inert

and motionless like a wonderful clockwork whose mainspring had been removed or a steam engine whose fires had been drawn." [24]

The significance attached to instincts in industry is perhaps best illustrated in Parker's studies of motives in economic life.[25] Man, according to this author, "is born into this world accompanied by a rich psychical disposition which furnishes him ready-made all his motives for conduct, all his desires, economic or wasteful, moral or depraved, crass or aesthetic." [26] Economic, as other forms of activity, is motivated by the demand for the realization of these instinctive wants, which are the efficient and tried guides of conduct, representing "the result of endless experiments of how to fight, to grow, to procreate, under the ruthless valuing mechanism of the competition for survival." [27]

Every instinct,[28] according to Parker, is subject to the Freudian formulae of repression, rationalization, and sublimation. If balked, it will break out in nervous disorder. If properly directed, its motive force may be sublimated into socially beneficial channels.[29] If an environment interferes with the play of these instinctive motives the human organism may undertake a complete, tenacious, and destructive revolt against it—a revolt which, in industry, may express itself in the form of mild restriction of output, of severe sabotage, or of a rising against the very form of organization itself. This revolt expresses not willful, responsible behavior, but a stereotyped reaction against these conditions. The forces which interfere with instinctive expression in the industrial environment include monotonous work, dirty work, specialized work, automatized work, the menial rôle of labor, insecure tenure of the job, injustice in hiring and firing, seasonal employment, etc.[30] Unhealthy fixations, irrational inferiority obsessions, are made part of the worker's personality by the presence of these conditions in his daily task.[31] Inferiority compensation finds its outstanding expression in the strike, the violence of which varies directly with the psychic annoyance, and which, in large part, reflects the mental ill-health generated by the worker's experience in the plant.[32] The ultimate effect of the interplay of these forces is a "true psychosis, a definite mental un-balance, an efficiency psychosis, as it were," which cannot

[24] W. McDougall, *Social Psychology*, New York, 1908, p. 44.

[25] C. Parker, *The Casual Laborer and Other Essays*, New York, 1920, pp. 197.

[26] *Ibid.*, p. 133.

[27] *Ibid.*, p. 135.

[28] The list of instincts used by Parker include sixteen, classified as follows:—Instinct of gregariousness; instinct of parental bent; instinct of curiosity; instinct of acquisition; instinct of fear and flight; instinct of mental activity; the housing or settling instinct; instinct of migration; instinct of hunting; instinct of anger; instinct of revolt at confinement; instinct of revulsion; instinct of leadership and mastery; instinct of subordination; instinct of display; instinct of sex. Compare with Tead's classification, Chapter XXIII, page 514.

[29] Z. C. Dickinson, *op. cit.*, p. 128.

[30] *Ibid.*, p. 48.

[31] *Ibid.*, p. 49.

[32] *Ibid.*, p. 51.

be cured by "our present moralizing and guess-solutions" or by "a ten per cent wage increase." [33]

The defence of the instinct hypothesis by Parker rests on a study of activities and conditions of work of migratory workers—the casual laborers—of the western and northwestern parts of the United States. However, according to this author, conflict appears wherever industrial conditions fail to satisfy the instinctive wants. This viewpoint is supported by DeMan,[34] as a result of a study, by the questionnaire method, of the feelings toward work, of 78 students of the *Academy of Work at Frankfort*. The majority of these were adult workers, including 12 students from the metal industry, 10 from publishing, 6 from transportation, 5 from public service, 4 from textile, etc. By analysing the questionnaires DeMan arrived at a summary rating on the favorableness of attitude toward work. Only 11 per cent of unskilled workers were found to experience joy in work, in comparison to 44 per cent of the semi-skilled and 67 per cent of the skilled workers. The relatively greater dissatisfaction with work of semi-skilled and unskilled workers is explained on the grounds of the intensified conflict between the creative and other important instincts and conditions of work in the less skilled tasks. Specialized work, repetitive work, unsatisfactory physical conditions of work, excessive fatigue, are stressed by this author, as they were by Parker, as factors at the source of conflict with instinctive motives, and of industrial unrest and dissatisfaction.

THE INADEQUACY OF THE INSTINCT HYPOTHESIS

In spite of the popularity, not so many years ago, of the instinct hypothesis, there is a tendency today to question the adequacy of a treatment of motives in terms of instincts. The chief objection to the instinct explanation of motives is that in the final analysis instincts are nothing more than logical abstractions.[35] There is no experimental evidence that they exist as actual structural entities or processes within the organism. As an aid in classifying human ways of acting the concept is probably useful, but the assumption that the instincts represent well-organized neurological or mental patterns of behavior is entirely gratuitous.[36] Equally fanciful, allowing for a moment the existence

of instincts, is the assumption that there are appetites or impelling urges "clamoring for gratification" [37] in the case of all the instincts. It is possible, for example, that in the cases of sex and hunger there are periodic chemical secretions in the body which create an over-whelming urge for the expression of these instincts. It is also possible that these instinctive tendencies can not be completely and permanently repressed without seriously influencing the stability of the individual. However, there is no reason for believing that such a condition exists in the case of curiosity, manipulation, defense, and other ways of acting that have been classified in instinctive groups by the proponents of the instinct hypothesis. To avoid this issue, as Freud has done, by insisting that all instincts go back to the sexual—by the injunction *cherchez la femme,* is merely another example of over-simplification of the problem—or the tendency to accept as "things in themselves" what are actually only distinctions and classifications.[38]

Another serious objection to the explanation of motives in industry in terms of instinct is the neglect of other forms of behavior in man. Such instinctive endowment as man may possess is quickly overlaid by habits of experience. To these must be added intellectual and volitional determinants of conduct which undoubtedly play a prominent part in creating motives-in-work. It is highly probable, as Dickinson [39] has indicated, that all of these are involved in the motivation of action and that the last word will only be said on motives when the last word has been written on psychology.

EXPERIMENTAL INVESTIGATIONS OF MOTIVES-IN-WORK

The appreciation of the inadequacy of the instinct explanation of motives has directed attention toward the need of the broader experimental investigation of the source of attitudes and activity in work. It is recognized that the analysis of motivating factors in work requires an application of experimental techniques similar to those which have been so successfully used in the study of accidents, monotony, training and other phases of work. It involves primarily an *accumulation and interrelation of facts* concerning the influences which determine the behavior of the individual in the industrial situation. In accumulating these facts the investigator may start with a hypothesis but the objective must be not that of finding facts which fit the hypothesis but of determining whether the hypothesis fits the facts. He discards such convenient labels as purpose, urge, desire, appetites, and similarly theoretical factors adopted on *a priori* grounds in the explanation of all behavior in industry. He adopts, for the study of motives, the uni-

versal methods of science—those of collecting facts and formulating conclusions only on the basis of established correlations among observed facts.[40]

Among the problems to be considered in such a fact-finding investigation of motives in work are questions as: What is the effect upon the mental attitude of the worker, more particularly upon his will to work, of various wage systems; of various wage levels, in relation to the purchasing value of money; of payments in money or in kind? What is the reaction to deductions from his pay for insurance or other purposes? How does he react toward the introduction of machinery, toward scientific management, and towards the effects of these upon the labor market and the relationship between labor and production costs? What is the relationship between the intensity of the will to work and the frame of mind of the worker on one side and production in general, the relationship to the working organization and the attitude or disposition of the worker toward the plant and toward production on the other side? What are the effects of working conditions in one industry or trade, as compared with another related industry, upon the stability of the worker? What is the effect of unemployment insurance upon the willingness or desire to work? How does the amount of sick benefits, in relation to pay, influence the tendency of the worker to report sick? What is the influence of working and living conditions upon the way in which the worker spends his free time, and how does this, at times, reflect itself in production?

The object of psychological investigations of this sort in industry must be that of determining the *related* conditions under which the worker reacts, in one or another manner, to wage systems, to a threat of discharge, to other factors which may influence his attitude toward and activity in the plant. These related conditions represent a complex pattern including, *on the one hand,* the physical and mental make-up of the worker and, *on the other hand,* the external conditions which play upon that make-up in the process of adjustment to work.[41]

The range of investigation in this field, as Kornhauser has pointed out, is almost unlimited. It can include an intensive study of the influence of hours, method and arrangement of wage payment, age, schooling, nationality, management, organizations of workers upon mental attitudes. It will involve a detailed and direct study of feelings and attitudes of individual workers by means of such scientific techniques as are available. It will lead to a comparison of different groups in the same plant and of different plants as an aid in the isolation of the exact factors which determine the attitude of the individual employee and the morale of the group as a whole.[42] It will invariably

and emphatically stress ***the observation of facts and their interrelation*** as the ***sine qua non*** of the scientific study of motives-in-work.

The German Industrial Inquiry

A beginning has been made in the study of motives in this way. Experimental methods employed in such investigations include the ***interview***, ***questionnaires***, ***rating scales***, and a ***direct examination of the effect upon production of changes in conditions of work***. Perhaps the most extensive of these studies, from the viewpoint of scope, is an inquiry conducted by the Efficiency Committee of the German Industrial Inquiry Board, under the direction of Lipmann.[43] This involved *first* an analysis of the statistics of many plants and *secondly* a direct interview of plant owners, plant managers, and plant workers.

The character of the observations made in this study can be illustrated by reference to the mining industry.[44] The period since 1913 has been marked by a tremendous increase in the use of machinery in the anthracite coal mines of Germany. Whereas in 1913, 95 per cent of the coal was mined by hand, through blasting, in 1926 the percentage of hand mined coal had been reduced to 33 per cent.

The newly introduced machinery has been objected to with great feeling by the workers, at least the older workers, mostly on the ground that work in the mechanized plants involves considerably more *bodily* and *mental* strain because of the noise and the greater claims upon attention. However, it was found that this violent objection on the part of workers to machines did not lead them to give up using the machines when they had the choice of using the pick axe. As a matter of fact, it was often noticed that the workers thronged to the plants using the machines, and even objected when an attempt was made to deprive them of compressed air hammers.

Such facts, according to Lipmann, must not be interpreted as meaning that the workers' objection was only "talk," and actually did not exist. For such a conclusion the reports of the workers are too general. One of the most important facts in explaining this contradiction is the conservatism of the miner. It is this which accounts for the antagonism of the older pick man, who has not yet accustomed himself to the compressed air hammer, which is greater than that of the younger man who has not worked long with the hand drill. So long as the worker is not familiar with the new working method he objects to it. He does not willingly work with the conveyor, but once he starts working with it he does not willingly leave it. An additional factor in the display of conservatism, in this particular instance, is the worker's unwilling-

ness to be deprived of the companionship available when the hand pick is used.

Of further importance in the miner's—particularly the older miner's—steadfast opposition is the fact that the machine deprives workers of jobs. Although it is true that the miners seek employment, perhaps even unwillingly, in the plants in which machines are used, because they can earn more in such plants than in others, at the same time they feel that the increased pay does not correspond with the increased expenditure of effort and to the increase in production.

Certain of the workers do not show a preference for the mechanized plant by reason of its machines, but by reason of a preference for the organization in the mechanized plant in comparison with the non-mechanized plant. The control in the non-mechanized plants is stricter, and a set quantity of coal is required from every man. The work is also more difficult because very close attention and considerable skill are required on the part of every man. In the mechanized plants, on the other hand, all that is required are regular work and a little "knack" which any worker can readily acquire. However, in other instances, the worker's objection to the plant with conveyors is based on the requirement in such plants that the worker perform a set task, whereas in the other plants, apart from the usual control, the worker feels fairly free at his work. So it is possible, in contradiction to what has been said before, that, in the case of certain workers, opposition to plants using machines may also reflect an opposition to the stricter organization in such plants, which is preferred by other workers.

Another illustration from the investigation can be used to show the dependence of the worker's reaction and attitude toward a situation upon the intrinsic and extrinsic factors active at that time. The danger of losing his job, according to Lipmann, may lead either to an increase or to a decrease in production. It leads to a decrease when there is an absence of urging, on the part of the plant management, due to the absence of a market for the product. In this case the worker tries to "stretch the work" and thereby to postpone discharge as long as possible. Increased production results when the worker believes that the least efficient workers are to be discharged first and the most efficient to be retained longest. No example can better illustrate the complexity of the situation and the inadequacy of arm-chair rationalizations on instincts and purposes. Findings such as these indicate clearly the need of study on the spot and personal contacts with workers and plant managers for an exact determination of the sources of feelings and attitudes in industry.

In addition to this German study there are a number of American investigations stressing the factual approach, each employing specialized techniques and contributing something in the way of findings, outlook, or procedures of importance in the analysis of motives.

Supervision as a Factor in Attitudes

Of interest among these is an investigation conducted in the Hawthorne Plant of the Western Electric Company, in which the interview method was employed in analyzing the attitudes of workers toward their jobs and toward the plant.[45] The study of the group of relay assemblers, described on pages 472–76, Chapter XXII, showed a continual improvement in the performance of the operators regardless of the changes made during the study. From this it was concluded that the increase in employee effectiveness was more closely related to an improvement in their mental attitudes than to any of the major variations introduced in the course of the experiment. An analysis of the conversations and comments of the workers showed that altered working conditions and the relative freedom from traditional supervision were the chief factors contributing to improved morale. These observations suggested that the same relation might exist throughout the entire plant and that the best way to improve workers' attitudes and morale was by approaching employees and asking them to express their opinions on the conditions in their working environment which they liked and disliked.

Such a study was undertaken in 1928, in connection with the development of a training course for supervisors which was being conducted in the plant at that time. The approach was first tried experimentally in the Inspection Organization, including about 1600 skilled and unskilled employees in shops and offices. Upon the completion of the preliminary investigation, in 1929, it was extended to other parts of the organization, including approximately 10,000 men and women operators.

The investigation involved a conference between trained interviewers and employees. Each worker was approached individually and asked to express his views. The employee was assured that he was invited and not ordered to express himself, for it was felt that voluntary comments would be the most reliable. It was also understood that if he agreed to an interview its contents would be entirely confidential; that neither names nor reference numbers were to be attached to interviews, and that identifying statements which might reveal the employee or his location were not to be recorded.

During the first part of this study interviewers started with a set of questions which they expected to have answered by every one. These were not in the nature of a formal questionnaire, but they delimited the general field of approach to what the interviewer thought important. Following several modifications in interviewing techniques, the plan was finally adopted of permitting the employee, after an explanation of the program, to choose his own topic. This method, known as the *conversational* or *indirect approach*, has the advantage, accord-

[45] M. L. Putnam, "Improving Employee Relations," *Pers. Jour.*, 8 (1930), pp. 314–325.

ing to the investigators, of stimulating the feeling of confidence, of giving the employee the benefits of emotional release, and of *fixing attention upon that which the employee considers important.*

An analysis and classification was prepared of comments voluntarily made by workers. At first only unfavorable comments were sorted out, but later both favorable and unfavorable were classified and compiled. This classification, given below, shows clearly the things in the plant in which employees are interested and which determine employees' attitudes and morale. If to comments on these topics are added references to supervision, treated separately in the analysis, there is developed a detailed picture of the factors which are basic in the motivation of workers in industry.

Absence	*Light*	*Social Contact*
Advancement	*Lockers*	*Steady Work*
Aisles	*Material*	*Temperature*
Club for Employees	*Monotony*	*Thrift*
Dirt	*Noise*	*Tools and Machines*
Fatigue	*Payment*	*Transportation*
Floor	*Placement*	*Vacation*
Furniture and Fixtures	*Restaurant*	*Ventilation*
Hospital	*Safety and Health*	*Washroom*
Hours	*Sanitation*	*Welfare*
Interest	*Smoke and Fumes*	*Working Space*

Of these factors payment is only one. Among these motivating forces, according to the investigators, *"the relationship between first-line supervisors and the individual workman is of more importance in determining the attitude, morale, general happiness, and efficiency of the employee than any other single factor."* [46]

This conclusion has led to the development in the Western Electric Company of training courses covering approximately 1000 supervisors. Comments made by the employees are used as the basis of the training program. In this way the employees' comments and opinions are brought back indirectly to supervisors whose consideration of them has led to a marked improvement in supervisory techniques.

Other by-products of this study can be mentioned. Those interviewed have had a chance to express themselves fully and to clear their minds of burdensome thoughts. As a result, supervision becomes easier. Morale is improved because the employee who has been interviewed is convinced that the management wants to better his surroundings and conditions of work. The company is obtaining first-hand information as to the effect of such incentives to work as thrift plans, pensions, sick benefit plans, athletic activities, vacations, etc. The management of Western Electric is convinced that it has progressed further in the

[46] *Ibid.*, p. 325.

knowledge of employee relationship during the short time that this plan has been in operation than in all of the previous years of the company's existence.

This study is significant, as Mayo [47] has indicated, as a development, in the study of motives in industry, of "the principle of accurate fact-finding—that has been humanity's most reliable guide in recent times."

The Questionnaire-Method in the Study of Attitudes

The value of such fact-finding inquiries and the variety of techniques that may be applied in measuring attitudes and motives are illustrated in an inquiry, conducted by Houser,[48] concerned with the attitudes of employees toward their executives and toward the organization employing them. The fundamental assumptions of this investigation are that employee attitude is the direct result of the activities of sub-executives, and that this attitude can be regarded as the principal test of the success of sub-executives. The measurement of workers' attitudes, therefore, enables chief executives to hold their subordinates definitely responsible for workers' morale, and to determine whether or not the sub-executive is fulfilling the responsibility imposed by new industrial leadership, that of fitting the exacting human needs of workers.[49]

Twenty features were selected as representing the most important elements of the working relationship between the employees and the organization.

"I. *Adjustment to Job:*
- Breaking in—new job.
- Opportunity to use experience.
- Clearness of instruction.

II. *Supervision:*
- Freedom to consult.
- Initiative and independence allowed in work.
- Judgments of results.
- Courtesy.

III. *Incentives:*
- Security of job.
- Welfare work (insurance, pensions, sick benefits).
- Remuneration.
- Adding to ability.
- Opportunity for promotion.

IV. *Participation—Expression:*
- New ideas or suggestions.
- Grievances.
- Knowledge of larger affairs (company and departmental).

[47] E. Mayo, "Changing Methods in Industry," *Pers. Jour.*, 8 (1930), pp. 326–32.
[48] J. D. Houser, *op. cit.*, pp. 226.
[49] *Ibid.*, p. 173.

V. *Working Conditions and Facilities:*
General working conditions.
Equipment, tools, etc.
Fellow workers.
Work schedule." [50]

A random sample of employees in the organization was then interviewed individually by a skilled interviewer—an outsider without knowledge or preconceived ideas about the organization. No names were recorded, so that the employees could have complete assurance of the confidential character of the interview. The interview was conducted, in this case, by means of carefully standardized questions, put always in the same way with the same inflections. The following questions, asked in connection with "adding to ability," are characteristic of the type used in this investigation. *"Are you learning things on your job that will be of use to you later on, either on this job or on a higher one? Are you getting a chance to learn and study some other job? How much do you feel that you are growing on the job?"* [51]

The employee's answer was carefully followed and graded by comparison with a rating scale consisting of 5 "type" responses, separated by approximately equal intervals from the viewpoint of degree of feeling. This scale had been memorized by the interviewer so that there was no need of referring to it in the course of the conference. The following "type" responses, used in grading the answers to the questions on "adding to ability," give an indication of the nature of the scoring criteria.

"5. *The company certainly does encourage me and offers me every opportunity to develop and make progress. I'm sure I am being given every chance I could be.*

"4. *Yes, there are a number of pretty good chances ahead. I believe I'm getting some new knowledge and ability every day. It could be a little better, perhaps, but the company takes an interest and that's an encouragement.*

"3. *The chance for learning here is all right, I guess—about average —no kick as far as I can see.*

"2. *You've got to pick most of it up for yourself. The job doesn't give you much chance. I've learned about all I can. I feel that more interest should be shown along this line.*

"1. *Don't think I'm getting along at all! I'm in a fierce rut! No chance to learn! There's no encouragement at all to try to learn or go ahead."* [52]

Each response was assigned a numerical value ranging from "1," lowest possible score indicating unqualified hostility, through "3," the

[50] *Ibid.*, p. 176.
[51] *Ibid.*, p. 177.
[52] *Ibid.*, p. 178.

middle point, indicating neutrality or indifference, to "5," the highest possible score indicating unqualified enthusiasm or favor. Scores below 3 show dis-favor while all scores above 3 indicate favor.

By adding the numerical values of the responses to all the questions and averaging the total, a single figure is obtained which expresses the attitude of the individual employee. The collective group attitude can be expressed in an average of the figures for all employees interviewed. In

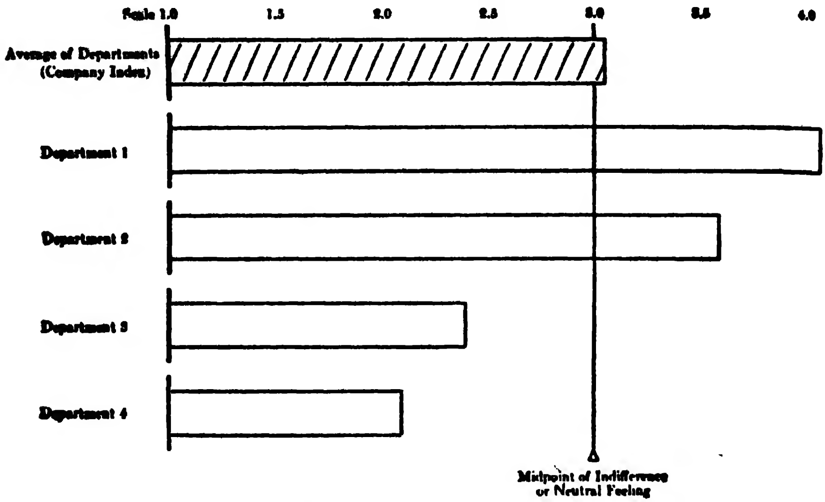


FIGURE 81. *Attitude of Employees in Departments.*
(After Houser)

addition, by averaging the scores for employees in individual departments, it becomes possible to compare the relative favorableness of attitude on the part of employees in different departments.

In Figure 81, are shown the results of using this method of measurement in 4 large departments of a company. It indicates clearly that whereas sub-executives in Departments 1 and 2 have been very successful in winning the favor of employees, and of establishing a favorable employee morale, the sub-executives in Departments 3 and 4 have been very unsuccessful in these respects. Although such measurement of attitudes is oriented by Houser from the viewpoint of improving the techniques of supervision, it also represents a useful method of studying the over-all attitude of the employee toward his work, for other purposes, and of making a more detailed analysis of the effect of specific motives in work.

The Multiplicity of Motives

The principle of fact finding in the study of motives finds its most recent, and perhaps most carefully controlled application in a study

by Kornhauser and Sharp,[53] conducted in the Badger-Globe Mill of the Kimberly-Clark Corporation. This includes an investigation of the feelings and attitudes of 200 to 300 girls employed on routine, repetitive machine and conveyor operations in connection with the manufacture of paper products. The investigators used both informal interviews and questionnaires personally administered to groups of about 50, each question being read aloud and explained when necessary. The interviews aimed to secure pictures of the girls as complete personalities with a tangled network of attitudes. The interviews were informal in character, but the interviewer was guided by a list of questions as an aid in suggesting directions in which material of interest might be sought.

The questionnaires, similar to those used by Houser, described on page 575, were prepared after considerable preliminary interviewing and represented an attempt to treat somewhat more objectively specific factors in the attitude situation.

The findings of this study, characterized by its very complete analysis of the factors which may affect the results, are too many to be cited in detail. A few may be used to illustrate their nature. One of the most significant is the discovery, in contrast to the findings of the Hawthorne investigation, that *"efficiency ratings of employees showed no relationship to their attitudes."* [54] As a matter of fact, in one group of 20 girls with comparable output records, three of the four with most unfavorable attitudes were first, second, and fourth in production, and the two most favorable were near the bottom in production. This may be related, according to the investigators, to the feeling on the part of some of the best workers that they were not properly rewarded in comparison to poorer workers.

However, the findings corroborate the Hawthorne study in demonstrating the rôle of supervisory practices as potent disturbers of workers' attitudes. In one department, A, only 29 per cent of the workers were shown to be favorably inclined by scores on a questionnaire measuring general attitude toward the job, while in Department B the figure was 71 per cent favorable. Similar differences appeared in all the more specific attitude-scores. The two departments were engaged in the same work; the employees were similar; hours, wages, and relations to the corporation were identical; physical conditions in Department A were a little better than in Department B. An intimate study of the attitudes and conditions of the two groups left no doubt that the one outstanding casual influence was the unfortunate nature of supervision in Group A. It is significant to note that negative feelings aroused by such supervision spread to other related matters, such as

[53] A. W. Kornhauser and A. A. Sharp, "Employees' Attitudes," *Pers. J.*, 10 (1932), pp. 393–404.

[54] *Ibid.*, p. 402. In this connection see the author's criticism of the Hawthorne conclusions on page 476, Chapter XXII.

working conditions, which were actually better for Group A in spite of the more pronounced dissatisfaction of the workers in that group with these conditions.

Other findings include low positive correlations (about .2 to .3) between individual scores on a psychoneurotic inventory and favorableness of attitude. The relationship between neurotic tendencies and unfavorable attitude is closest in those departments where there is greater strain and dissatisfaction. This illustrates the inter-relation of intrinsic and extrinsic factors, and the importance, for adequate interpretation of industrial attitudes, of including both the subjective and objective explanatory factors and of striving to see them as part of a single whole or pattern.

Other interesting results include the observation that the work attitudes of "those with unhappy home life" prove to be no more unfavorable than the average. The fear of losing the job or temporary lay-off, looms as an important factor in determining the feelings of the worker. An analysis of the results shows that "little things" are not themselves of extreme importance in upsetting morale. They are important as they fit into a generally unsatisfactory situation, in other words, where there are insecurity, inadequate awards, bad treatment by supervisors, frustration in work, to nourish them. Minor sources of irritation are bound to occur, but the extent to which they will become deeply embedded in the feelings of the worker depends upon the soil which is prepared for them.

The general impressions concerning work-attitudes left by the study of this group of girls are described by the investigators in the form of a clinical picture of a typical group of American young women engaged in routine factory work, in a small town of the Middle West in the year 1930. "The girls are still children. For many, management is a new, bigger, stronger parent. Going to work is much like going to school—only harder. Work is neither an evil nor a blessing, it is just the way of the world, unquestioned. Religion is more or less the same. One prays and goes to church because one always has done so; it is the normal, natural thing to do. Similarly, one works. There is no lasting joy or satisfaction in work, no sense of accomplishment; but likewise there is little positive resistance or antagonism, little need to drive one's self to work. After all it does bring the indispensable dollars with which to help out at home, and with which to purchase permanent waves and freedom from family authority. About the only alternative to the factory is housework, and most prefer the factory with the greater independence it affords. Ambitions are very moderate. Few girls expect to get anywhere in or through their work. Almost all look forward, as a matter of course, to marriage and children. Dreams for the future are largely dreams of a prince charming. There is almost no working-class feeling or political and economic radicalism. Like children, the girls live for the day—or for the two

or three hours left to them outside of work—and for the week-end. Household duties, quiet home interests, church activities, movies, dances, parties (of all kinds), cards, auto-rides, radio—these are the centers of interest. Work merely occupies their time." [55]

The Influence of Skill upon Attitude

A somewhat novel approach to the analysis of motives-in-work has been undertaken by Fairchild as part of the study of skill and specialization in terms of therblig-skill-averages, described in Chapter IX. In this, detailed schedules, rating scales, and correlation techniques were employed to determine the place of skill, as well as job, wages, conditions of work, "sense of capacity," etc., as sources of satisfaction in work—satisfaction being defined as "a sense of actual contentment or enjoyment coming to a man from a particular experience." [56]

A comparison of 4 plants showed that those in plant A tended to find their main satisfaction in *wages and conditions of work;* in plant B satisfaction arose primarily from *conditions of work* supplemented by the *wages and the job*. In plants C and D, on the other hand, workers found their satisfaction primarily in the job. At plant C conditions ranged a close second, with wages ranging low, while at plant D, wages ranged second and conditions were distributed evenly. Inasmuch as both mean and median skill indexes increase from plants A to D,[57] the conclusion is drawn that where skill exists to a considerable degree it becomes the first source of satisfaction to the workman. Conversely satisfaction in conditions of work or in wages becomes the predominating factor only where satisfaction in skill has materially decreased.

The results of the study suggest to the investigator that "failure to utilize men's capacity for skill development is like failure to utilize the capacity of a waterfall flowing past one's factory doors, or of the coal in one's bins to its fullest extent. It is a waste of a natural utility directly at hand, whose use would be advantageous to every one concerned. . . . To develop a skill or technique in any line of activity, whether in music, art, sport, or industry, is to harness a torrent of rushing waters and turn it to effective account. Skill is needed in industry today not simply as a bargaining asset for the workman, nor only to supplement mechanical contrivances which have not yet been perfected to the point where they can do the entire work unattended. It is needed as a fundamental psychological requirement of the workman. And it presents a vast resource, which is now only partially exploited, for increasingly efficient production." [58]

[55] *Ibid.*, p. 404.
[56] M. Fairchild, "Skill and Specialization," *Pers. J.*, 9 (1930), p. 136.
[57] The means of the S. I. vary from 67.2 to 108.5 between plants A and D respectively. (See Chapter IX, pages 160–64.)
[58] M. Fairchild, *op. cit.*, p. 142.

"Caste" as a Source of Motivation

The studies of motives-in-work so far considered, with the exception of that by Mathewson,[59] have made use of questionnaires or of interviews conducted by investigators openly recognized as such by the workers. A more indirect approach, involving casual case-studies, is illustrated in inquiries by Whiting Williams [60] who spent many months working on railroads, in mines, in factories, etc., in an attempt to get a first-hand view of the reaction of workers to their jobs, to their associates, to their managements, to their own home problems, and to such other activities as might influence their desire to work and their interest in work. Among the impressions concerning the source of motivation—or the "main-springs of men"—left with Williams as a result of his "overalls" experience is the recognition that one of the fundamental factors in man's attitude toward his work is his pay check. The worker who walks to and from work for a week because his child has unexpectedly worn out an extra pair of shoes, cannot help but be governed by the immediate compelling importance of regular and adequate pay. Living on the margin of bare subsistence anything which will effect his earning capacity, either immediately or in the future, brings a rapid and certain response in the defense of the continuity of his job. The narrowness of the "blanket" separating him from three meals a day and shelter and dependence goes far in explaining the wary defense against anything which means curtailed rates or curtailed employment. It explains the lack of reality to the marginal worker of a bonus system which provides payment in the future instead of an immediate addition to salary; of any participation in management which does not favorably effect his pocketbook or help to regularize employment. "The Boss he wants a muchness of *his* money 'cause he can wait, but what Ah wants—and what Ah gotta *have* is not a muchness of money but a quickness," [61] justifies much of the worker's apparently adverse reaction to distant dividends as unreasonable and unwise as they may appear to the wider-margined observer.

However, as compelling as is this pressure for the Saturday night's earnings, this constitutes only a prologue to the play of motives in industrial life. "If this mere first act were only the whole of the play, then the scientist could surely hope some day to discover a satisfactory formula for wage revision." [62] What makes this unlikely is that the pay check's ability to buy material things, particularly when this is beyond the margin of the hunger minimum, is over-shadowed by the ability of the job and the check to buy an intangible something of equal importance and of vastly greater intricacy—viz., his standing among his fel-

[59] S. B. Mathewson, *op. cit.*

[60] W. Williams, *What's in the Worker's Mind*, New York, 1920; *Full Up and Fed Up*, New York, 1922; *Mainsprings of Men*, New York, 1925, pp. 313.

[61] W. Williams, *Mainsprings of Men*, *op. cit.*, p. 18.

[62] *Ibid.*, p. 27.

low workers. Chief among the sources of motives-in-work is *"the surprising vastness of the gap which everywhere among the workers separates the holder of a 'swell' job from the holder of a 'bum' job, and most of all divides the possessor of* ANY *job at all from the luckless vagrant who possesses none and knows not where to find one."* [63]

Throughout industry there is found a system of caste based on *work* corresponding roughly to the more familiar hierarchy of caste based on *property*. The laborer transferred to the millwright gang, receiving only an additional 2 cents per hour, gets an immediate transformation in social status reflected not only in the congratulations of his fellow-workers but in the acceptance of his wife and family by those who had hitherto looked upon them as somewhat lower in the social level.[64]

The miner leaving his job at two o'clock in the afternoon to go fishing is seeking not so much the pleasure of fishing as the recognition of his superior laboring status evidenced in his freedom to control the hours of his work. In laying off early he tells his companions the same story that the manager tells by means of a new automobile, or of a new home. Conspicuous leisure becomes the mark of successful attainment among his fellow-workers.[65] *Everywhere among the workers, the nature of his job and not solely the earning power demands the social standing awarded the worker by his fellow-citizens.* The recognition of this fact is, according to Williams, essential to a complete understanding of why man works and the basis of dissatisfaction in work and industrial unrest.

Other factors unquestionably play a part. Among these, according to Williams, are:

1. *The amazing ignorance, on the part of employer and employee, of each other's deeper purposes and desires.*[66]

This attitude appears clearly in the voluntary limitation of output. Such restriction represents in part a fear of lack of work, a protection against speeding up and it also represents an essential unfriendliness to the employer—an attitude not to the work but to the arranger of it. This attitude is not instinctive in character but is acquired in the course of experience at work and represents one of the most fertile sources of industrial unrest. At the same time, because it is acquired and not instinctive, there is reason for trusting in the possibility of modifying the attitude through a re-arrangement of those conditions which produce it.

2. *The unbelievable importance of the worker's feelings and experiences rather than his logic or reason as a factor in all his viewpoints and attitudes.*[67]

This follows, according to Williams, from the superior inertia of the intellectual or working pressure as compared with the emotional pres-

[63] *Ibid.*, p. 3.
[64] *Ibid.*, pp. 56–57.
[65] *Ibid.*, p. 293.
[66] *Ibid.*, p. 3.
[67] *Ibid.*, p. 3.

sure. This means that the search for the source of attitude and action in industry must be at the level of emotional and not at the level of intellectual behavior. This search, as has been suggested by Mayo and others, may lead us into the morass of irrational revery, the almost impenetrable maze of personality disorders, great and small, which develops when the wells of the emotions are dried or pour forth their content in an unending torrent.

3. *The complete impossibility of walling off the factory from the home, the worker from the citizen, of dividing the hankerings of a man's working hours off from those of his hours of leisure.*[68]

"These dockers," a British labor leader explained, "simply can't keep going for more than three or four weeks at a time. But this does not prove that they dislike to work. These men slow down simply because they are the victims of the wear and tear of weeks of 'overtime' sandwiched in between weeks of depressing waiting and searching for a job. I have observed that irregular work always tends to make an irregular worker. An irregular worker, in turn, is practically bound to make an irregular citizen."[69]

Other factors are important, but the prime element is the wish to enjoy the feeling of worth—recognition and respect on the part of others. This starts, as Burns[70] has pointed out, with the feeling on the part of workers not only that they have rights, because labor made civilization, but that they also have duties because civilization depends for its continuance upon their work. The worker's point of view implies that a railwayman, an engineer, a machinist, an oiler, is bound, just as "intellectual" workers, by the honor of a calling. There is pride in it—pride in the work one does and in its necessity. To "count," to be considered worthwhile, because of his job, is the initial demand of the industrial worker. To understand the strength of this motive, the force of its interplay with encouraging approvals and opposing disapprovals is, according to Williams, to know the mainsprings of acting in industry.

Cyclical Variations in Emotions and Attitudes

The essential unity of the job, the home, and the organic balance of the individual in determining attitude toward work is stressed by Hersey,[71] as the result of an intensive study of 12 men for a period of a year and of 5 others for periods of several months. Throughout this period each worker was carefully studied with respect to (1) overt behavior, such as efficiency, lateness, co-operativeness, verbal outbursts, constructive ideas, absenteeism, etc.; (2) emotional behavior; (3)

[68] *Ibid.*, p. 4

[69] *Ibid.*, p. 183.

[70] C. D. Burns, *The Philosophy of Labor*, London, 1925, p. 34 ff.

[71] R. B. Hersey, "Periodic Emotional Changes in Male Workers," *Pers. J.* 7 (1929), pp. 459–463.

R. B. Hersey, "Rate of Production and Emotional States," *Pers. J.* 10 (1932), pp. 355–64.

dominant traits in thought and revery; and (4) physiological items such as blood pressure, colloid content of blood, weight, hours of sleep, illness, feeling of fatigue, etc.

The investigator spent the entire working day in constant contact with the subjects as well as a considerable portion of the time after working hours. Each worker was fully informed of the purpose of the investigation. Changes in emotions were recorded on a numerical scale ranging from *worry* with a value of —6, through *sad* (—4 to —5), *peevish* (—1 to —2), *neutral,* that is "indifferent" (usually zero), *interested*—joking, co-operative—(+3 to +4) to *elated* with a numerical value of +6.

An analysis of the findings shows a definite periodicity in emotional tonus which could not be accounted for by environmental happening, climatic changes, or physical conditions, but which definitely affected the feeling of effort and performance on the job. The cycle of changes from "low" to "low" ranged from 3 to 9 weeks, but in no case did the length of the period of a given individual vary by more than a week from his own average. The changes occurring in the worker with the change from high to low emotional tonus show the typical characteristics listed below.[72]

	High	*Low*
Production:	Work comes easily; production is at least average, often above; fewer complaints are made about the way the work is going, though one is likely to get less done than he could, due to interest being attracted by all sorts of stimuli in the environment and willingness to take work and its importance less seriously; ready to stop and tell the other man how to do his work.	Usually no more than average is accomplished unless worker is driven; tendency towards less; work an effort; its difficulties exaggerated. On skilled work, however, requiring planning, or in executive work, sometimes more is accomplished than in manic phase, due to saving of time and effort by sticking to the job on hand. In purely repetitive work necessity of keeping production up to standard likely involves great physical cost. Low phase often affords starting point for creative spark, which later manifests itself in manic culmination—birth of genius.

[72] R. B. Hersey, *op. cit.*, p. 462.

	High	*Low*
Effort:	Usually felt to be less than production.	Greater than production.
Feelings of fatigue:	Usually not many.	Always more.
Sleep:	Less.	More.
Blood pressure:	Apt to be higher.	
Weight:	Often slightly lower, if two periods close together.	
Sexual energy:	Apt to be greater.	
Extra-plant activities:	Many.	Few.
Psychic attitude:	Powerful over the environment; tendency toward anger over rebuffs rather than pessimism; joking and laughing; confident; looking toward betterment and opportunities to enjoy the beauties of the world and himself; hard to handle; best way to stimulate him with a problem; praise and criticism both have little effect.	The world weighs heavy; the worker hates to be forced to meet crises; assimilates rebuffs and criticism with difficulty; needs encouragement and praise at lowest period, a whip to force him into proper efficiency after starting up the cycle; more ready to be suspicious and irritable, downcast and worried; ready to quit or at least to talk about it on slightest provocation.
Mental pictures:	Objective, real, day-dreams likely to end in action immediately; how to get ahead and better himself often in his mind though he may not be dissatisfied with particular job.	Subjective, pessimistic, unreal, fanciful.

Although no final explanation of this apparent cyclical variation can be given on the basis of these few case studies, the findings, according to Hersey, suggest a possible association with variations in the general relation between energy spending and energy building mechanisms

involving (1) metabolic activity, (2) sex and other ductless gland functioning, and (3) autonomic nervous equilibrium.

SUMMARY

The analysis of experimental studies of motives-in-work confirms the opinion that the financial incentive represents only a preliminary step in tapping the resources of the worker. The findings suggest that the level and consistency of production are determined by a wide variety of variables which require careful study and control for the attainment of maximum yield, satisfaction and fitness on the part of the individual worker. Explanation of motives in terms of "instincts," "desires," "habits," or other blanket terms represents a naïve simplification of a complex situation. The ways in which workers are hired, trained, paid, promoted, disciplined and dismissed are important determiners of attitude.[73] Curt treatment by superiors, monotonous, meaningless work, lack of opportunity for self development, excessive fatigue, the unreasonable use of punishment [74] will be deeply felt. Such factors mould attitudes, constitute the sources of motives, and produce the ineffective, unfit worker and the savage industrial rebel. The exact value of each of these and other factors, and the pattern of their interplay, are questions which are far from fully answered, although there are encouraging signs in the investigations which have been cited.

"Whatever the difficulties and whatever the poverty of present knowledge, the problems are so central and inescapable and so clearly problems of industrial psychology—if it chooses to be a social science as well as a managerial technique—that it appears well worth our while canvassing the possibilities of further promising research in the field. Among the few greatest questions of our age is that which asks what modern industry means to the individual worker with reference to his satisfactions and fullness of life." [75] The accumulation of evidence and the formulation of adequate scientific explanations of the factors basic to these represent a challenge to industrial psychology.

[73] J. D. Houser, *op. cit.*, p. 4.
See G. H. Miles, *The Will to Work*, London, 1929, pp. 79.
[74] See Chapter XIX, pages 405–06.
[75] A. W. Kornhauser, "The Study of Work Feelings," *Pers. J.*, 8 (1930), p. 351.

XXVI. THE MALADJUSTED WORKER

Adjustment at work represents the major objective in using the procedures for selection, training, elimination of fatigue and monotony, etc., described in other chapters of this text. In spite of the application of these methods individual instances of maladjustment still occur. This follows in part from the dynamic or changing quality of human personality. The young man who, at the time of employment, is satisfied with a routine clerical task, and who can satisfactorily perform the task, becomes increasingly dissatisfied and perhaps grossly maladjusted if deprived of an opportunity for promotion to a more responsible job. Conditions arising outside of the plant, over which the management and supervisory force have no control, seriously affect both the production and the morale of the worker. Resistance to new methods of work, "slowing up," growing irritability, etc., associated with increasing age, serve gradually to unfit the older worker for his job. In addition, vocational maladjustment is a reflection of *emotional maladjustment,* a term used by Fisher and Hanna[1] to describe the wide variety of *psychotic disturbances* of personality which affect individual adjustment in every phase of life. The adjustment of the individual requires an *integration* of conflicting tendencies to the demands of the activity in which he is engaged.[2] Emotional maladjustment follows from a conflict in the individual of impulses which are incompatible with one another.[3] It reflects a disturbance in the integration of opposing tendencies into the unified and purposive pattern of behavior which is the essential characteristic of the "normal mind" and of the "happily adjusted individual."[4] Maladjustment, from this viewpoint, grows out of a failure to knit together contending impulses and to contrive an adjustment to the situation which is satisfying to the individual and effective in so far as the demands of the situation are concerned.

EMOTIONAL MALADJUSTMENT AS A FACTOR IN VOCATIONAL MALADJUSTMENT

The adjustment of an individual in the home situation, in the play situation, in every other phase of his daily activities requires a congeniality, a compatibility, a harmonious relation between the indi-

[1] V. E. Fisher and J. V. Hanna, *The Dissatisfied Worker,* New York, 1931, pp. 260.
[2] W. H. Burnham, *The Normal Mind,* New York, 1925, p. 27.
[3] B. Hart, *The Psychology of Insanity,* Cambridge (England), 1912, p. 57.
[4] W. H. Burnham, *op. cit.,* p. 38.

vidual and the situation.[5] It demands a proper balance in the "total situation" constituted by the "self and the stresses occurring between it and its environment." [6] In work this balance is established when the individual is reasonably efficient, when he attains a reasonable degree of satisfaction from the work, and when his activities are conducive to the welfare of the social group of which he is a member. A failure to achieve any one of these three objectives in work constitutes maladjustment. This may follow from a lack of aptitude for the work, from inadequate training, from a disregard of disturbing working conditions, etc. It most frequently follows, where such conditions are adequately controlled, from an inadequate emotional adjustment of the individual to major aspects of his life—to superiors, to inferiors, to family situations, to sexual problems, to competitive aspects of daily life, etc. The individual whose emotional balance is disturbed for any reason whatsoever will express this not only in his relations at home, in his social group, but also at work. His emotional maladjustment, whatever it relates to, "breeds within him dissatisfaction and thwarts him in his search for happiness and success. Inasmuch as his feelings and emotions are inherent aspects of himself, he carries them with him, so to speak, into every situation which he enters. Now, since he does not usually know the reason of his dissatisfaction, does not understand the whyfor and nature of his maladjustment, it is not surprising that he very frequently attaches or attributes it (his dissatisfaction) to his work or his working situation. He then feels dissatisfaction with his work and becomes a vocationally maladjusted individual." [7]

THE SYMPTOMS OF EMOTIONAL MALADJUSTMENT AT WORK

It is impossible within the scope of this text to discuss fully the concept of normality and the symptoms and causes of emotional maladjustment. Such a discussion would necessarily involve a complete review of the entire field of abnormal psychology.[8] It would lead into a critique of the classic description of the nature and causes of mental disorder by Kraepelin and Janet and the more recent psycho-analytic doctrines of Freud, Adler, Jung, and others.[9] For the purpose of this

[5] V. E. Fisher and J. V. Hanna, *op. cit.*, p. 21.
[6] W. Koehler, *Gestalt Psychology*, New York, 1929, pp. 329.
[7] V. E. Fisher and J. V. Hanna, *op. cit*, pp. vii-viii.
[8] See W. Eliasberg, "Grundriss einer allegemeinen Arbeitspathologie," *Schrift. Psych. Beruf., Wirt*, 28 (1924), pp. 41.
[9] Among texts which will be helpful to the reader interested in a discussion of the concepts and points of view of abnormal psychology are:—W. H. Burnham, *The Normal Mind*, New York, 1925; B. Hart, *The Psychology of Insanity*, Cambridge (England), 1912; G. Murphy (Editor), *An Outline of Abnormal Psychology*, New York, 1930, (Modern Library Edition); J. J. B. Morgan, *The Psychology of Abnormal People*, New York, 1928; W. S. Taylor, *Readings in Abnormal Psychology*, New York, 1926; J. K. Folsom, *Social Psychology*, New York, 1931; F. A. Moss and T. Hunt, *Foundations of Abnormal Psychology*, New York, 1932.

Among the original source material which should be familiar to the student in the field

text it seems sufficient to sketch briefly the most characteristic symptoms of emotional maladjustment, and to depend upon the discussion of industrial investigations and the case studies cited below for an elaboration of detail.

The overt expressions of emotional maladjustment are multitudinous in character. Not infrequently, for example, manifestation takes the form of *blaming others for one's failure.*[10] In such cases fellow-workers, foremen, the management, and even social standards and customs may be burdened with the responsibility for the individual's lack of success. Wives do not give encouragement, fellow-workers do not co-operate, or superiors fail to recognize the superior qualities of such individuals. Compensation for thwarted desires is achieved through a condemnation of associates, supervisors, conditions of work or, in extreme instances, of some single person, perhaps even as remote as a high government official, who has placed himself in the way of the individual's progress.

In other instances those whose self-assertion finds no outlet, or who are thwarted sexually or socially, manifest a *disintegration* of impulses in *self-pity, jealousy, lack of co-operation.*[11] The slave-driving tactics of the "hard-boiled" foreman often represent his compensation for impeded self-assertion in *pretending to be the opposite of what he actually is.*[12] As some men "sport" the latest car or indulge in outward display of affluence in the face of a limited income to impress their neighbors, so the supervisor falls back on a loud and dominant tone of voice to bolster up his feeling of insecurity—*a feeling of inferiority.*[13] There are numerous other manifestations of emotional maladjustment. The most common overt expressions of such maladjustment may, according to Fisher and Hanna, be divided into two groups.

"I. *Manifestations of the milder emotional maladjustments*
- (1) Petty jealousies
- (2) Mild forms of self-pity
- (3) Lack of cheerful co-operation
- (4) Fault-finding
- (5) Hard-boiled tactics and labor agitation
- (6) Desire for undue attention, feigned bravery, and foolhardiness as a retreat from fears.

"II. *Manifestations of the more serious emotional maladjustments*
- (1) Frequent change of jobs

of abnormal psychology may be included:—A. Adler, *The Neurotic Constitution,* New York, 1917; A. Adler, *Problems of Neurosis,* New York, 1930; A. A. Brill, *Fundamental Conceptions of Psycho-analysis,* London, 1921; S. Freud, *On the Psychopathology of Everyday Life,* London, 1914; S. Freud, *Introductory Lectures on Psychoanalysis,* London, 1922; C. G. Jung, *Psychology of the Unconscious,* New York, 1917; Abraham Myerson, *The Psychology of Mental Disorders,* New York, 1927; P. Janet, *Les medications psychologiques,* Paris, 1919; E. Kretschmer, *Physique and Character,* New York, 1925.

[10] V. E. Fisher and J. V. Hanna, *op. cit.,* pp. 111–112

[11] *Ibid.,* p. 172.

[12] *Ibid.,* p. 173.

[13] *Ibid.,* p. 114.

(2) Extreme reticence and withdrawal
(3) Tired feelings
(4) Spasmodic and irregular application
(5) Day-dreaming
(6) Deficiency in range and power of attention, distractibility
(7) Extreme irritability
(8) Nervous indigestion, nausea
(9) Abnormal fears, fear neuroses
(10) Feelings of being spied upon, watched or followed
(11) Hearing voices
(12) Miscellaneous symptoms." [14]

The sources of these disturbances, according to the same authors, may be classified under three general headings.

"(1) *Those resulting from emotional immaturity, emotional infantilism.*

"(2) *Those resulting from the exaggeration or over-expression of one or more drive-emotions.*

"(3) *Those resulting from decidedly unnatural or abnormal expressions of drive-emotions,* i. e., from substitutive forms of activity which are neither satisfying to the individual nor contributory to the welfare of the social group." [15]

The significance of these factors in individual cases will appear in the case studies cited below. Before proceeding with these it seems desirable to refer briefly to the general aspects of a few industrial investigations which have demonstrated the significance of emotional disturbance as a deep-seated source of maladjustment at work.

THE INCIDENCE OF EMOTIONAL MALADJUSTMENT AT WORK

The experience of many investigators in the field of mental hygiene has pointed to the importance of emotional maladjustment in interfering with adaptation at work. Toulouse,[16] for example, estimates that the annual loss in earnings to French workers suffering from mild psychopathic disturbances reaches hundreds of millions of francs. According to Fisher and Hanna [17] one half of the amount expended annually because of labor turnover is spent on the replacement of emotionally maladjusted workers. Assuming the average cost of breaking in a new worker to be $45.00,[18] turnover cost in this group would amount to $4500.00 for a firm employing an average working force of

[14] *Ibid.,* p. 209.
[15] *Ibid.,* p. 72.
[16] E. Toulouse, "Le budget de la psychopathie dans le travail," *Rev. de la Sci. du Trav.,* 1 (1929), pp. 41–50.
[17] V. E. Fisher and J. V. Hanna, *op cit.,* pp. 233–234.
[18] See Chapter VIII, page 116.

500 men with a labor turnover of 40 per cent. To this must be added the higher cost of supervision of the emotionally maladjusted worker and of increased absenteeism, reduced output, etc.

Although there has recently developed a renewed emphasis upon psychopathic disturbance as a factor in vocational maladjustment, as early as the beginning of the present century Janet, of France, and Wetterkamp, of Germany, drew attention to the incidence of vocational maladjustment among patients whom they saw at their clinics for the mentally disturbed.[19] The analysis by Adler,[20] in 1917, of 100 cases of unemployed patients, ranging in age from 25 to 55, observed in the Boston Psychopathic Hospital, points also to the importance in vocational maladjustment of *paranoid personalities* displaying such traits as suspiciousness, contentiousness, inability to survive in competition; of *inadequate personalities* including feeble-mindedness and disturbances of the judgment; and of *emotional instability,* characterized by moodiness, outbursts of temper, impulsiveness, etc. According to Jarrett [21] the effectiveness of approximately half the working force is disturbed by either minor or major emotional maladjustment, requiring intensive analysis and training. Stevens [22] reports that in a group of store workers numbering about 4000 the diagnosis of "Functional Nervous" disturbances was made 506 times in a 6 month period from October to February inclusive. This term is used to designate an heterogeneous group of symptoms causing impairment that cannot be ascribed to physical defects. In this group are included patients with complaints variously classified as "run-down condition," "nervousness," "nervous exhaustion," "nervous breakdown," etc. This is unquestionably a cover-all for many, as are most of the conditions included in the classification of emotional maladjustment by Fisher and Hanna. During the 6 month period "functional nervous disorder" stands fourth in order of frequency among the complaints treated in the store Health Department. About 10 per cent of all workers manifested disability from such complaints. During the same period 1,546 days of working time were lost from this cause by 123 individuals. This comprises about 9 per cent of the total time lost through illness.

A recent study by Anderson [23] has led to the conclusion that approximately 20 per cent of the employees of mercantile establishments may be called "problem" individuals. Among 1200 employees representing a fairly representative group, that is, "run of the mine" employees of R. H. Macy and Company, 19 per cent of the sales people

and 23 per cent of the non-sales force were found to present conditions that caused their department heads to question their value as personnel risks in the store. A large proportion of these conditions represented personality disturbances, and were not the outgrowth of intellectual conditions or of factors on the job itself which might interfere with adjustment. Included among workers suffering from personality disturbances were persons who had never "grown-up"; whose experiences instead of maturing and ripening had simply carried the faulty characteristic of adolescence into adult life, producing the underdeveloped, inadequate, difficult, poorly integrated or unstable workers, commonly called "job misfits," or "work failures," or "mediocrities," or "ne'er-do-wells." [24]

TABLE 70

Personality Types

	LOW COST	HIGH COST
	per cent	*per cent*
Extrovert	54	11
Ambivert	36	49
Introvert	10	40
	100	100

(After Anderson)

As one step in his inquiry Anderson [25] made a clinical study of 284 sales clerks selected on the basis of "selling cost or production rating." The average "selling cost" for the department as a whole was determined. Those in the upper 25 per cent from the viewpoint of sales cost were designated as "High-Cost" salespeople and those in the lower 25 per cent as "Low-Cost" sales clerks. In addition, the investigator selected a second group consisting of 100 sales people chosen by general agreement of the floor superintendent, department manager, and training representative, as the "Best" and "Worst" sales clerks in typical departments of the store. Table 70 shows the diagnosis made by the investigator of the personality types of the "High-Cost" and "Low-Cost" groups. A marked predominance of introversion is evident in the former group. A study was also made of the personality disorders of the two groups. The percentage in each group of "maladjusted, poorly integrated, unstable personality, handicapped by conflicts and complexes, faulty attitudes, irrational thinking, pessimistic reverie,

etc.,"[26] is shown in Table 71. It can be seen that 6 per cent of the high-cost-of-selling cases and that none of the low-cost group suffered from serious personality disorders.

TABLE 71

PERSONALITY DISORDERS	LOW COST GROUP	HIGH COST GROUP
	per cent	*per cent*
None	57.7	50.0
Mild	42.3	44.0
Serious	.0	6.0
	100.0	100.0

(After Anderson)

The incidence of personality disorders among "Best" and "Worst" sales clerks is shown in Table 72. Twenty-four per cent of sales clerks included in the worst group show serious personality disorders, in contrast to the total absence of such serious disorders among the best sales

TABLE 72

Showing Personality Disorders Among "Best" and "Worst" Sales Clerks

	"BEST"		"WORST"	
DISORDERS	*No.*	*per cent*	*No.*	*per cent*
None	39	78	11	22
Mild	11	22	27	54
Serious	0	0	12	24
	50	100	50	100

(After Anderson)

clerks. The clinical examination of the "Best" and "Worst" sales clerks revealed the clinical symptoms shown in Table 73. Ninety-four per cent of the worst sales clerks and only 22 per cent of the best deviate from average normal mental health. This, according to Anderson, "probably more than any other single factor differentiates the 'Worst' sales clerks from the 'Best.' The adjustment difficulties which the 'Worst' sales clerks so commonly exhibit at their work are but the expression of personality, intellectual and general bodily conditions that

[26] *Ibid.*, p. 239.

render such individuals poor personnel risks, unless adjustment is made possible through psychiatric treatment." [27] There seems to be reason for questioning Anderson's classification as perhaps too much influenced by the abnormal orientation which the psychiatrist brings into his clinical study. The value of the results is also disturbed by the highly subjective character of the criterion in selecting the "Best" and "Worst" groups. However, the findings are suggestive in so far as the general trend of influence of personality disturbance upon adjustment at work is concerned.

TABLE 73

PSYCHIATRIC CLASSIFICATION	"BEST"	"WORST"
Borderline mental defect	1	1
Neuro-syphilis	0	1
Psychopathic personality	0	13
Psycho-neurosis	5	4
Mild depression	1	0
Senile deterioration	0	4
Inadequate personalities with intellectual handicaps	0	14
Fatigue	1	2
Unclassified personality disturbances	3	8
No abnormal findings	39	3
	50	50

(After Anderson)

A STUDY OF TELEGRAPHIST'S CRAMP

The significance of emotional disturbances in creating maladjustment has been strikingly confirmed in a recent study by Smith, Culpin, and Farmer.[28] This involved an examination of a group of telegraphists certified as suffering from an occupational disorder known as "telegraphist's cramp," and of a group who were free from this disorder. The investigation included the use of (1) an ergographic test, (2) the McDougall-Schuster Dotting Test, (3) the Graphic Pursuit Meter, (4) an examination of pressure exerted on the key, (5) a medical examination, and (6) a study of the emotional make-up or development of the individual by means of general observation of overt behavior and of carefully framed questions in the course of an interview. A group of learners in telegraphy and of workers in allied occupations were also examined as a control upon the major experimental group of telegraphists.

Of the 41 cramp cases examined 31, or 75.6 per cent, showed symp-

[27] *Ibid.*, pp. 254–255.
[28] M. Smith, M. Culpin and E. Farmer, "A Study of Telegraphists' Cramp," *Ind. Fat. Res. Brd. Rep.*, No. 43 (1927), pp. 44.

toms which would lead (quite apart from the cramp) to the diagnosis of minor mental disturbances or mild psycho-neurosis characterized by anxiety, obsessions, or hysteria. In 26 cases the symptoms were of a serious nature. Of the 46 non-cramp subjects only 15, or 32.5 per cent, had psycho-neurotic symptoms in varying degree. The distinction between the individuals suffering from psycho-neurotic symptoms and those free from these symptoms is well brought out in a summary, by the investigators, of the outstanding characteristics of each type. Not all of these traits are necessarily found in any single individual, but they are roughly typical of those free and those suffering from psycho-neurosis respectively.

"*A. B. finds his work interesting, and looks forward to getting on at it—goes in for sports or hobbies—is sociable, enjoys being with his fellows—if shy at first with strangers becomes less so with experience—respects authority but is not overwhelmed by it—can be observed without undue emotion, has no particular fear of the dark, noises, etc.—doesn't worry about his work when it is finished—sleeps well—can go at an easy pace in telegraphy—can hold his own opinions with and against his fellows—can realize himself in relation to others reasonably. An approximation to this we should call normal, particularly if combined with a healthy physique and cheerful expression.*

Y. Z. thinks the work interesting, but is doubtful whether he is making progress—is never sure of himself—worries when he has done a thing as to whether it is right—is conscious of being watched in trains, buses or restaurants—goes back to make sure he has done what he thinks he has—likes to check his work many times—dislikes all games and social activities—doesn't feel at ease with people—irritated and frightened by authorities—speculates on the possibility of the floor giving way or the building falling down—upset by noises—always wants to rush at dots. Such a type we should class as psycho-neurotic and under the conditions of telegraphic work we should anticipate the development of cramp.[29] *An ultimate breakdown will be modified by the natural vitality of the person, but given two people of the same vitality and conditions of work A. B. will carry on efficiently where Y. Z. will break down.*" [30]

Other differences were found between the cramp group and the non-cramp group. The first group is weaker from the point of view of efficiency on the tests and generally exercises heavier and more irregular pressure on the sending apparatus. However, these test differences do not clearly distinguish between the two groups, by reason of the great amount of over-lapping. There is a very definite trend with respect to the greater incidence of psycho-neurosis in the group suffering from

[29] In other occupations where there is no specifically recognized occupational disease, people of this type would tend to have a "nervous breakdown" or if physically very strong to have abnormal work curves or be "difficult."

[30] M. Smith, M. Culpin and E. Farmer, *op. cit.*, p. 20.

telegraphists' cramp. The commonest picture of a cramp subject is the presence of severe psycho-neurotic symptoms allied to muscular weakness.

Of 100 young learners who were interviewed, 54 showed no predisposition to psycho-neurotic breakdown; 27 could be described as slightly unstable; 19 showed definite psycho-neurotic tendencies and of these 6 reflected them in such an acute form as to permit classification in one of the recognized groups of psycho-neurosis. These findings suggest the possibility of differentiating at the age of 16 those who, by reason of psycho-neurotic tendencies, will most likely develop a maladjustment in this occupation in the form of telegraphists' cramp. It is interesting to note that the objective tests alone will not distinguish these groups.

Among clerical workers the proportion of subjects with symptoms indicating liability to psycho-neurotic breakdown was found to be approximately 20 per cent. There is evidence that such subjects tend to suffer "nervous breakdowns," but such maladjustment as occurs from this in work does not take on so highly a specific form as "cramp" in the case of the telegraphists. In the latter "cramp appears to bear the same relation to other symptoms in the same patient as do such recognized psycho-neurotic manifestations as stammers, tremors, and functional paralyses. It occurs in conjunction with anxiety and obsessional states; it occurs in a form obviously hysterical; and it occurs as an isolated symptom in perfectly healthy subjects who present no other abnormal manifestations. In a large proportion of cases it would appear that treatment should be directed to the general condition, of which cramp is only the most conspicuous system. It is probable that attention given to the emotional state of the patient when cramp first appears might in some cases suggest a means of preventing the development of the trouble." [81]

THE CLINICAL STUDY OF MALADJUSTED WORKERS

The control of maladjustment at work, whatever its source, involves a thorough study of every employee who has become a "problem" or who shows signs of disturbed adjustment by reduced efficiency; in growing irritability and laxness in work; by a multiplication of complaints, or exaggerated concern about himself or his work; etc. Such a study involves a complete review of every factor which may influence the worker's adjustment.[82] It entails essentially an application to vocational maladjustment of the clinical method of individual study, developed by Witmer,[83] which has been used so successfully in the treatment of maladjustment in the school, in the home, and which has been

[81] *Ibid.*, p. 36.
[82] M. S. Viteles, "Clinical Methods in Industry," *Ind. Psych.*, 3 (1928), pp. 753–58.
[83] L. Witmer, "Clinical Psychology," *Psych. Clin.*, 1 (1907), pp. 1–7.

specifically applied in the transportation industry in the rehabilitation of accident-prone drivers.[34]

The application of the clinical method involves a detailed study of every element in the situation which may influence individual adjustment. It requires a complete examination of every aspect of individual ability, temperament, interests, etc., that may promote or interfere with fitness at work. It involves a health examination, an investigation of social background and an analysis of the behavior of the individual at work and away from work. It leads into a careful study of the job environment into which the individual is placed, and of the processes of production, supervision, etc., with which he is faced.[35] However, the point of emphasis in such clinical study is the *individual*—an individual looked upon as an integrated organization of behavior patterns —as a "whole" personality against a background of objective conditions to which he is called upon to adapt himself.[36]

The clinical method discards the "atomistic" viewpoint of an earlier psychology [37] and emphasizes the dynamic concept that "just as a watch or a machine is not merely so much iron, copper, and the other elements that chemical analysis would show, nor even so many wheels, rods, plates, and other parts; so a man is neither a mere aggregation of chemical elements, nor is his mind a mere accumulation of desires, habits, and other components," that "the whole is something quite distinct from its parts, and to understand the whole one must not merely know what each part is and what it is doing, but must know the relationship between them and even more what the whole is doing." [38] The emphasis, in this approach is upon the "total situation"—upon the balance which exists between the highly complex interrelated variables which influence individual adjustment.[39]

A few case studies may be used to illustrate the procedures of clinical study and the results accomplished through their application.

AN EXAMPLE OF THE CLINICAL STUDY AND TREATMENT OF EMOTIONAL MALADJUSTMENT

A case cited by Anderson [40] will serve to show the effect of personality disturbance upon work and to indicate the methods employed in discovering the source of such disturbance and in its treatment.

"Case No. 3. Female. Age 48. Sales clerk.

Problem: Acting peculiarly on the floor, and complaining bitterly to her

Buyer of the persecutions of her associates, she was referred to the Conference Office for psychiatric study.

Study: In the Conference Office this woman showed an acute anxiety state; was in great distress with marked depression. She says, "I have not been able to sleep or eat for five whole days." (Cries and wrings her hands.) "I saw a tall detective lean over and whisper to a girl at the —— counter, and he said, 'You watch that woman, she is a thief, and is stealing from the store.' Then there are two elderly women who have put the girls up to watching me, and the girls pass up and down the aisle saying, 'Keep your hands off the ——, etc.' They whisper to each other about me and wink in a knowing way as if to imply they are on to me. They are all talking about me."

A careful investigation was made, and it was disclosed that the employee had seemed ill for several days, but that for weeks she had been very "nervous," stayed by herself, was over-sensitive and "imagined" things. There was no basis for suspecting her honesty; nothing was missing from her department and she was considered one of the most valuable sales clerks in the store, and regarded by all as thoroughly reliable.

Her aged mother had been seriously ill for several months, and at this time was near death. This employee was up with her a great deal at night and as a result had lost much sleep. She also had to do the housework and the cooking, which, with the arduous duties of the day as a sales clerk, had brought on acute fatigue. Such a condition, in a distinctly psychopathic personality, who for years had exhibited an unstable nervous system, on to which was engrafted an anxiety as to the possible death of her mother, and the possible loss of her job inasmuch as she was falling down in her work, finally resulted in a full-blown mental disturbance.

In our examination we found her suffering from well-marked delusions of persecution, retardation of thought processes, with a depressed emotional state and slowing up of bodily movements.

She was placed at once under psychiatric care, reassured regarding her job and her department worries. A social service worker and nurse were sent to her home, and for a few days she was kept in bed and carefully nursed. In time she began to recover, returned to the store, was placed back in her old department under the best possible controlled conditions, in the hands of a Buyer who was not only sympathetic but intelligently understanding. In the end she recovered and is still with the store as a valuable employee.

Follow-up: Ten months later her buyer reports, "She is doing very well, and no longer seems worried or fearful." One year and a half later, her Buyer reports, "She is good and in her present capacity, I couldn't do without her. There is no problem or complaint." Her section manager says, "Miss —— is satisfactory, and a very efficient sales clerk." [41]

The basic factor in this case is constitutional in character. It is the make-up of the individual, a *psychopathic personality,* which disintegrates under the stress of the environment. The case also furnishes an interesting example of the possibility of re-adjustment *right within the department* by which the worker is employed. Such a procedure makes unnecessary the unproductive trial-and-error transfer to which

[41] *Ibid.,* pp. 210–211.

personnel divisions often resort in an attempt to re-adjust the worker. A careful clinical study discloses the underlying cause of this difficulty and makes possible treatment which will fit the cause.

OTHER FACTORS IN VOCATIONAL MALADJUSTMENT

Although emotional maladjustment is a basic factor in vocational maladjustment there are many instances in which performance at work and satisfaction derived from the job are disturbed by factors which are more or less external to the individual. The effect of such factors is illustrated in a case study made by the author as a part of a program for the clinical examination and adjustment of taxicab drivers [42] employed by the Yellow Cab Company of Philadelphia. In the organization in which this study was made, as in the case of almost every other similar organization, wages are paid in the form of a commission upon gross earnings. In the present instance, at the time of the study, drivers received 33⅓ per cent of their collections, supplemented, of course, by tips which are equal, on the average, to one-half of the commissions collected by the drivers.

The analysis of the earnings of drivers hired in the year of 1924 and in the employ of the company in 1927, when this study was made, showed an average difference in earnings of $600.00 per year between the 25 per cent "Best" earners and the 25 per cent "Poorest" earners.[43] There was a maximum difference of over $1000.00 a year. A preliminary intensive analysis of the mental, physical, social, and economic factors affecting earnings showed that such items as age, marital conditions, number of jobs held during the years prior to employment by the company, and physical condition affected adjustment, and that data on these factors obtained on the application blank could be used in the elimination of a proportion of poor earners prior to employment.[44] But, and this is possibly the most important contribution of the study, there were shown to be significant differences in the causation of maladjustment in individual cases. Poor health made it impossible for one man to work as steadily as required for good earnings. In other instances the fact that the driver was a single man, without family responsibilities, and free from a social incentive for increasing earnings, held a more prominent position. In still other cases there were indications that psychopathic disturbance of personality was responsible for maladjustment. The multiplicity of causes in the case of all the "Poor" earners, and the frequent dominance of a single cause

[42] A brief discussion of the methods employed in this study is to be found in an article entitled "The Clinical Method in Industry," by M. S. Viteles, published in *Ind. Psych.*, 1 (1926), pp. 753–58.

[43] See Chapter VI, pages 58–60.

[44] See Chapter X, pages 182–83.

in the case of the individual driver, suggested the possibility of re-adjusting "Poor" earners in the employ of the company on the basis of a clinical study of each individual case.

This study was made by the author as ***consulting psychologist*** for the organization. It included a review of all the factors of individual make-up, of job environment and methods of work, of home and other social conditions constituting the "total situation." The procedures employed included a thorough physical examination by the company physician; the application of standard tests of intelligence, temperament and business knowledge; visits to the home by the social worker; an analysis of the very complete personnel records maintained by the organization; and a series of interviews with the individual driver. The findings from the application of these procedures were summarized by the psychologist and presented to a Weak-Sister Committee [45] which, on the basis of the findings, outlined a program to be followed in the rehabilitation of the driver. This committee included the company physician, the social worker, the superintendent of the garage at which the driver was employed, a street supervisor, and the assistant general-manager of the company, sitting under the chairmanship of the consulting psychologist. The case study cited below is presented as typical of the reports considered by this committee and of the action taken. It also illustrates the influence of a non-constitutional factor—in this case the loss of the wife—upon the adjustment of the worker.

Case of Driver A. B., Seniority Number 00000.

Problem: The driver was reported by the garage superintendent by reason of (a) a slump in earnings, (b) an apparent failure to "stick to the job," as shown by low daily mileage records and increased absences, and (c) a change in attitude expressed in "unwillingness to co-operate" with the superintendent, and a "low state of mind."

Appearance and General Factors: A. B. is a native born Philadelphian, 34 years of age, 5′ 7½″ in height, weighing 185 pounds. At the time of the interview A. B. had been in the service of the company approximately 4 years. He is a widower, having lost his wife about 3 months before the date of the interview. Education includes 1 year in a senior high school. His application score at the time of employment would have been 362, or considerably above the passing score.[46]

Health: Poor health not a factor in the maladjustment of this driver. In his 4 years of service he has made only two visits to the Medical Department and has been O.K.'ed off on only two occasions. His physical efficiency is rated "A" by the Medical Department. The Dental Department reports a rating of "A" on mouth condition. There have been no payments from the health insurance fund to the driver during the period of employment.

[45] The "Weak-Sister Committee" was so named because drivers whose gross income and net earnings were inadequate were commonly known among the drivers as "Weak-Sisters." Technically a "Poor" earner or "Weak-Sister" was defined as a driver falling into the lowest 20 per cent of the entire driving force from the viewpoint of earnings.

[46] See Chapter X, pages 182–83.

Work Record:

(1) *Prior to Employment by Yellow Cab Company.*

This is A. B.'s first term of employment with the Yellow Cab Company. From 1910 until 1914 he ran a poultry farm in the southern part of New Jersey. Between 1914 and 1917 he worked as a machinist for the Remington-Arms Company, and from 1917 until 1921, first as a truck driver and then a machinist at Hog Island (shipyard). From 1921 to 1923 he was employed as a taxicab driver by the Quaker City Cab Company, and since 1923 he has been in the employ of the Yellow Cab Company of Philadelphia.

(2) *Service with Yellow Cab Company.*

A. B. is working on the 9 to 7 Day Shift with Friday as his "day off."

In his 4 years of service A. B. has had 3 charged and 16 suspended accidents. Twenty-two speeding charges appear against his record. At the present time he has 160 merits to his credit, having been demerited 3 times for A.W.O.L.; twice for lateness, and 15 times for speeding and reckless driving.

During the last 12 months A. B. has drawn $1009.50 in commissions, an average daily wage of $3.59 for the number of days worked. These earnings are below average, but not sufficiently low to place A. B. in the category of outstandingly poor earners. As a matter of fact, he appears on the weak-sister list, on the average, only 6 times per year of employment. The driver claims that tips have been averaging about $10.00 a week. The average number of days per week worked for the year is 5.4. This means his absences average approximately ½ day a week. This is not excessive in comparison with the general working force.

During the interview A. B. claimed that about 50 per cent of his jobs were "wire" jobs, that is, obtained by calling the Traffic Department from one of the many stands maintained by the company. This statement, however, is not borne out by an analysis of his daily sheets, which show that 39 per cent of his jobs were "wire" jobs.[47] A further analysis of the sheets revealed that the majority of "pick-up" jobs were from stands and not obtained while "cruising."

A study of the daily mileage shows an average of 48.4 miles per day, which is very low. This is a definite indication that the driver is not spending a sufficient portion of his time "cruising" or driving on the streets. A. B. not only fails to cruise sufficiently, but he seems to have trouble getting started. In some cases it took him from one hour to two hours after starting work in the morning to get his first job. Another important feature is that only 44 per cent of his total mileage is "live," whereas 56 per cent of the total mileage is "dead" mileage.[48]

A further analysis of the sheets shows that the driver seems to concentrate his efforts on a few stands located in approximately the same section of the city.

The analysis of the operating records showed that there has been a distinct drop in earnings in recent months. On the last 10 sheets, for example, the gross daily income averaged $8.40 and the average daily commission $2.80, which is 70 cents less per day than the average for the entire year.

Social and Economic Factors: The most important item which appeared in

[47] In the taxicab business, in general, a good earner obtains his work not by depending on the Traffic Department, but by cruising around the streets, planning his day so as to be during each part of the day in that section of the city in which most business is to be obtained.

[48] The ground covered by the cab when carrying a passenger is known as "live" mileage; other mileage is "dead" mileage.

the analysis of social and economic factors was the loss of the wife. For a short time prior to her death the driver had been separated from his wife. Since her death the driver's two children had been living in an orphan asylum, the driver paying for their maintenance at the rate of $5.00 per week. In general, the driver appears to maintain himself and his family at the marginal level. At the time of the interview he had no saving account or reserve of any kind on which to fall back in case of an emergency.

Test Data: On the general intelligence test A. B. obtained a score which is slightly below the average of the poorest earners. His score of 110 on a test of business knowledge is approximately average for the group. The latter test suggests that his chief weakness is lack of a knowledge where to look for work at different times of the day.

The answers given by the driver on the *Woodworth Personal Data Sheet* [49] give no indications of emotional disturbance. The score on the *Colgate Personal Inventory* C-2 suggests that personality tends in the direction of introversion, but the percentile rank does not definitely place the driver in the introverted group. Perhaps the most significant comments made in these tests by the driver are that he "is not very argumentative, that he seldom makes friends and keeps all his troubles and worries to himself."

Interview Data: The most significant findings appeared in the course of the interview. The results of the interview agree with the results of the personality tests in showing an absence of personality disturbance. Mediocre ability combined with a generally "weak" or non-aggressive personality may account for the fact that A. B. is consistently somewhat below average in earnings. At the same time he has always maintained satisfactory adjustment to fellow-drivers, to supervisors, and with respect to attitude on the job. In addition, earnings, although low, have been high enough to keep A. B. out of trouble.

During an early interview the driver maintained that the recent slump in earnings resulted from the absence of business on the street. He repeatedly stated that he "was out to make as much money as he could" and that he consistently "goes after business when business is to be found." His attitude was that of blaming his drop in earnings on the generally less satisfactory business conditions which exist in the industry during the Summer months.

In later interviews the essential facts came out. In the first place, it appears that the wife's death had not been natural, but the result of suicide. There was a slight tendency of the driver, in his day-dreaming, to accept the blame for this suicide. This tendency was not expressive of a psycho-neurosis, but reflected the doubts of a normal individual whose marital life had not been particularly happy. This is unquestionably a factor in the driver's maladjustment. In addition, the driver has been paying a visit every day to the orphan asylum in which his children had been placed. Inasmuch as the institution could not be visited during evening hours, A. B. has been contriving to be in the neighborhood of the orphanage sometime during the day. This appears to account in a large part for the low operating mileage record. In most instances the visit had been made during the early part of the morning. This explains the almost consistent failure to obtain riders during the first few hours of work, to which reference has been made above. The increase in number of absences during recent months is

explained by the fact that the driver has taken off a number of Saturdays in order to spend them with his children.

Action of the Weak-Sister Committee: This case study was reviewed by the Weak-Sister Committee. The discussion brought out the fact that the garage superintendent was generally aware of the change in home conditions but had not obtained all of the facts which had been elicited in the course of the interview. It further developed that the driver had asked for a change to the 11:00 to 9:00 Day Shift, but had been refused permission to change because his seniority did not entitle him to this more desirable shift. Upon reviewing the case the Weak-Sister Committee recommended that the driver's request for a change in shift be allowed, so as to give him an opportunity to visit his children during the first part of the morning, in the belief that having made this visit A. B. would start work promptly and regularly at 11:00. The superintendent was also advised to maintain contact with the driver as a means of promoting a stabilization of favorable attitude toward himself and toward his work.

Follow-up: A follow-up at the end of 30 days and 60 days respectively showed that the change in shift had been made, and that there had been a marked improvement in the driver's attitude. In addition, the level of earnings had been restored to that maintained prior to the clinical analysis of the factors underlying disturbed adjustment.

"OLD AGE" AS A FACTOR IN MALADJUSTMENT

Among the many causes of maladjustment "old age" is a specific factor which is attaining increasing importance in accounting for maladjustment at work. This follows in large part because of the difficulty experienced by the worker beyond middle age in adjusting himself to the increased psychological demands imposed by the rapid rate of change of working conditions in industry.[50] The findings of recent studies of learning by adults, to which only bare reference can be made here,[51] have shown that such difficulty as the older worker may have in learning new methods of work follows not primarily from a decline in learning ability, but from an atrophy of acquired learning habits as a result of disuse.[52] As Thorndike[53] has pointed out, if the adult worker fails to learn, inability due to age will very rarely, if ever, be the reason. "The reason will commonly be one or more of these: He lacks and always has lacked the capacity to learn that particular thing. His desire to learn is not strong enough to cause him to give proper attention to it. The ways and means he adopts are inadequate, and would have been so at any age, to teach him that thing. *He has habits or ideas or other tendencies which interfere with the new acquisition, and which he is unable or unwilling to alter.*"[54]

In case of workers an important factor in promoting maladjustment is the failure to keep pace with changing methods of work. This follows, in part, from the amount of unlearning required for new learning after old and inconsistent habits have become well set. Old viewpoints and old methods of working become firmly established and set up resistance against their replacement by improved methods of work. This results, in part, from stagnation and, in part, from the failure of management to keep before the old workers the importance of continued change, of continued learning as a necessary factor of adjustment to work in modern industry.[55] Stagnation and resistance to new methods of learning and a natural decline in ability through disuse affect not only manual employees but clerical and managerial workers.[56] The evidence of it in the case of the last group is to be found in the difficulty of even young executives to adapt themselves to re-organizations that follow a change in management in an industrial organization.

In addition to the growing disuse of learning ability, the approach of old age is characterized by changes in personality make-up. As Martin and deGruchy [57] have pointed out, workers approaching middle and old age tend to become talkative and garrulous, critical of co-workers and employees. They set themselves up as paragons of virtue and condemn in no uncertain terms the failings of younger members of the organization with whom they come into contact. "Summarizing the characteristics of the old, one may say that their physical and mental reactions are slowed down, that they are inflexible, slow to catch new ideas, that their prevailing emotions are disagreeable, that they are dependent and tend to look backwards, that their imaginations use only past experiences for present-day needs, that they incline to slovenliness and laxness in daily living and that they are forgetful and even untruthful in dealing with the past." [58] Although there is no ex-

[55] The significance of these facts with respect to the development of training programs for adult workers thrown out of employment by *technological changes* in industry has been pointed out by Thorndike. "The facts of adult learning may also encourage industry to face changes in machinery, processes, and the like with the hope of reducing disturbances by education of the workers. The writer, at least, is sure that the hand weavers who were thrown out of work by the invention of the power loom could in most cases have been taught not only to use the power looms, but also to make them and repair them, or to be useful in whatever factory work or trades were short of employees at the time. A steady, industrious, reliable worker has qualities of body and mind and morals which are too important to be wasted because some industrial change has destroyed the value of the special work which he has hitherto performed. Public or private provision for his education for some suitable work seems highly desirable, and likely to cost less and succeed better than has been supposed. His fear of failure and of being an object of unpleasant attention or ridicule, accentuated by the depressed condition which the loss of his habitual living and life tend to produce, should be allayed or allowed for so far as possible. General awareness and acceptance of the truth about adult ability to learn, and a wider prevalence of adult education will help in this. If his new education is as one of a group in similar circumstances and is provided without the imputation of inferiority to him it will be more acceptable and more successful. (E. L. Thorndike, *op. cit.*, p. 180.)

[56] E. D. Smith, *op. cit.*, p. 8.

perimental evidence on the nature of these changes, there is reason to believe that these too are not the result of the mere passage of years, but reflect the influence of extraneous factors affecting the motivation and attitudes of older people.

With approaching "old age" there also appears an actual physical slowing-up that may interfere with the productive efficiency of the older workers where speed is a factor in the situation. Industrial experience and everyday observation of older adults favor the impression that old age is accompanied by a slowing-up of the voluntary muscular processes. Recent experiments by Miles,[59] involving tests of manual motility and reaction speed applied to 863 subjects, 6 to 95 years of age, with approximately the same number in each decade, show a small decrement in these functions with increasing age. However, none of them is large enough to show that age alone dictates the score variance, which appears to depend as much or more upon the sum total of other factors as it does on chronological age.[60] In interpreting his findings Miles suggests the theory that the slower and more difficult action in the old is brought about by neural conservation mechanisms that are built up or become more potent with increasing life-time. "A particular decrement according to this theory would not be chiefly chargeable to a defect in the mechanism but to a positive check on it—a neural governor device protective of the mechanism. The weight of years may be in large part neural inhibition—interference to action. This is perhaps the core, or the basic behavior element, in the caution and proverbial good judgment of the old. Surely the self-depreciation and inferiority attitudes exhibited by the majority of older people in reference to action are scarcely warranted from our data. Decrement appears more in feeling than it exists in fact."[61]

The Clinical Study of "Older" Workers

The evidence from these diverse studies of old age indicates, as Smith has pointed out, that the problem of middle-aged and older people to meet the demands of modern industry is not primarily due to the effect of advancing years. "Practical experience confirms the results of the psychological laboratory that the principle effect of the passing years is that they provide an inescapable exposure to the influences of what a man does and experiences as the years pass. The power of men to continue to acquire and to develop habits gives to increasing years the opportunity to offset any slight decline in faculties or change in temperament which might occur, by increasing skill, information, seasoned judgment, and personality qualities adapted to the requirement of his circumstances. But the same power also gives to the

[59] W. R. Miles, *Change of Dexterity with Age*, Proc. Soc. Exp. Biol. and Med., 29, 1931, pp. 136–138. W. R. Miles, *Measures of Certain Human Abilities Throughout the Life Span*, Proc. Nat. Acad. Sci., 17, 1931, pp. 627–33.

[60] *Ibid.*, p. 632.

[61] *Ibid.*, p. 633.

passing years the opportunity for learning powers to fall into disuse and atrophy, for undesirable habits of thought, action, and personality to form, harden, and to escape from conscious control or even conscious recognition." [62] The nature of the middle-aged or older man is thus essentially dependent upon what he does with the years.

The re-adjustment of the individual "old" worker, as in the case of other workers in industry, involves, as a basis for re-adjustment, a clinical study of each as a means of determining the factors which have restricted development or produced unfavorable behavior patterns. Pioneering work in this field has been done by Lillien J. Martin, who personally, as well as in her scientific studies, exemplifies the possibility of continued accomplishment with increasing age. A hitherto unpublished case study from the files of Dr. Martin may serve to illustrate the procedures and possibilities in the re-adjustment of the older worker.[63]

DEPARTMENT STORE.....A.2.

FILE NO. 1201

January 19, 1931.

CASE OF MR. E........... R..............
Department ....Cotton and Silk Yardage
Age ....61 years
Time Employed ....38 years in this store
Physical Ex. ....Good plus.
Personnel Dept. Report ....Decreasing output, fewer customers, drop of 31 per cent during last 5 years. Highest salary in sales force because of long service. Highest selling cost in the store.

Psychological Examination Results: Extremely slow reactions both mentally and physically. Attention turned in, observation good for detail and in special fields. Memory good, stocked with past material, no new content. Psychically soft with marked avoidance of everything that causes physical or mental effort. Ethical values narrow and antiquated. Imagination fair but stocked with old store of memories. Humor singularly lacking. Suggestibility nil. Literal interpretation of life.

Daily Program: Mr. R . ... is a bachelor who lives alone in a three room apartment. Up at 7:30 A. M. Prepares his breakfast and does some housework. Street car ride of 3 minutes to the store. At noon takes his lunch alone at a nearby cafeteria, about 2 minutes walk from the store. Although he has a light meal the full hour is consumed by the time he gets back to work. Leaves store at 5:45 P. M. Shops for his dinner and rides home. Prepares dinner, more housework. Spends an hour after dinner listening to the radio while he reads the paper, comic strip and crossword puzzle is preferred. Sometimes this time is spent playing solitaire, listening to the radio. Bed at 9:30 P. M.

[62] E. D. Smith, *op. cit.*, p. 10.
[63] Published through the courtesy of Dr. Lillien J. Martin.

There is no deviation EVER from this program. On Sundays he spends the forenoon in thoroughly cleaning his apartment. Then prepares his dinner and in the afternoon goes to the movies or a base ball game, according to the weather.

He has no outside interest of any kind. His only worry is his store record which he realizes is getting poorer and poorer. This he attributes to the low cost of ready-to-wear clothing, and the indolence of the modern mother who does not trouble to sew for her family. "The times have changed" he repeats with a sigh, and of course, he implies for the worse. He is good at rationalizing as far as his imagination permits . . . but is not very convincing as when he states that he does not take more physical exercise because he fears he might, "at his age," raise his blood pressure, but as his mental life is as torpid as his physical, one suspects that any effort is distasteful to him. He does not think that he is particularly slow in response but has the greatest satisfaction in the "exemplary life" he has mapped out for himself. His virtues are his undoing. He is handling his store work as he does his housework, with meticulous care and vast attention to detail. He is constantly folding and smoothing out the bolts of goods. "I get irritated," he says, "when I see such a waste to the store in mussed goods." (Typical rationalizing.) Watching him at work one sees that one of his fundamental difficulties is a false sense of values. The goods being kept in order is more important to him than getting it sold. The potential customer is allowed to wait, sometimes beyond her endurance, and turns away, one suspects, to return no more.

Psychotherapy Advised.

1. Discussed in detail the slowing down, both mental and physical, that has been allowed to take place, chiefly due to his living alone. That he has no gauge, by so living, by which to measure his tempo since no comparison is made with other individuals. Showed him where social contacts are especially good for holding up his speed and recommended that he transfer the membership he had as a young man in the East in a fraternal organization, to the West, to attend all the evening meetings and to take an ACTIVE not a passive part.
2. Discussed why the customer comes first in department store work. Saw that his view of the job is very narrow and limited to a little special knowledge, so:
3. Pointed out that the kind of virtue that means stagnation is not given first place in our estimation, but to try and replace it by a goal of self-development and increased knowledge and life experience for his personal happiness and efficiency.
4. Gave time exercises. Each morning he is to time himself in replacing yard goods on the shelves, unfolding goods, etc., and to time himself and increase his speed until he has brought himself up to normal. Early morning is best for this exercise and he is to practise this for 10 or 15 minutes. He will probably hesitate to begin this exercise as he feels our idea of his slowness is a personal one, which indicates how little he is aware of his deterioration in activity that has been allowed gradually to take place.
5. Every day he is to read and discuss with his fellow-workers matters pertaining to department store selling.
6. Never again is he to lunch alone but each day he is to seek out other employees or arrange to lunch with new acquaintances for the sake of talking

over current affairs. This is to help him reanimate his mind and force him to a more sustained attention.

7. To look on all new acquaintances as potential customers of the store, thus building up a clientele. This is to be regarded as a part of his responsibility to his job.

8. The whole matter of amusement as recreation, stimulation and personal development was discussed.

9. A daily program chart was given for him to fill in for 2 weeks when he returns to the clinic.

Second Visit.

Good response, more intelligent grasp of suggestions than we had expected. He has joined a local lodge of Masons and attends 1 evening each week. Has made application for membership to a boating club and will, if accepted, join March 1st and go boating on Sundays. Is reading 1 Trade Journal and *Time* and using his reading for lunch hour discussion.

Repeated the points of the first interview and suggested that he find some woman who is alone with whom he can become friendly. He need not report again unless he so desires.

July 1, 1931.

Sales Report.

February	10%	increase	in number	of customers over February, 1930	
March	22%	"	"	"	(3 special sales days)
April	14%	"	"	"	
May	19%	"	"	"	
June	21%	"	"	"	

This brings him up to average for the number of customers for this department and drops his selling cost to normal.

Mr. R ..... reported to talk over progress outside of the store which has been very satisfactory. Only trifling worry over loss of 4 pounds in weight but as he could lose 12 pounds more with good effect, he was easily brought to see the absurdity of this. Has a woman friend who invites him to supper once a week and he follows this by taking her to a movie. Seems well pleased that this friend does not want a supper after the show and has figured that he is the gainer in money by this arrangement.

CASE CLOSED

AGENCIES FOR THE RE-ADJUSTMENT OF WORKERS

The Psychological vs. the Psychiatric Method in Industry

Among the problems to be considered in connection with the vocational re-adjustment of workers is that of the agency to be employed in analyzing the causes of maladjustment and in treatment. Southard [64] has recommended the use of a "mental hygiene working party" composed of a psychiatrist, a psychologist, and a psychiatric social worker. This is essentially the organization that has been employed in recently

[64] E. E. Southard, "The Modern Specialist in Unrest," *J. of Ind. Hyg.*, 2 (1920), pp. 11–19.

organized child guidance clinics. It is represented in the set-up of the "conference office" in the R. H. Macy & Company organization. In this instance the conference office is a division of the personnel department which includes also the training department, the employment office and a social service department.[65] In such a set-up the psychiatrist is generally looked upon as the executive who administers the adjustment program.

In other organizations a staff consisting of a clinical psychologist and necessary assistants qualified in the field of mental testing and in the investigation methods of the social service worker, has been employed to make the necessary case studies and to direct the adjustment program. Regardless of whether the director of this program is a psychologist or psychiatrist, he must be thoroughly grounded in the principles and techniques of general and applied psychology, and have a thorough knowledge of the theoretical and practical aspects and procedures of abnormal psychology.[66] In the opinion of the author there are a number of striking differences in orientation between a clinical psychologist and a psychiatrist which favor the employment of the former to direct this activity of the personnel organization. Chief among these is the *psychologist's orientation toward the normal* as contrasted with the *psychiatrist's orientation toward the abnormal.*[67] At its very beginning, psychology set about to discover the laws that underlie the behavior of the average or normal human being.[68] So concerned were psychologists with the average or normal that, in early experiments by Wundt and others, results with subjects who showed extreme variation from the average were discarded as being of no value in formulating the general principles of human behavior. In the study of individual differences, the problem was oriented as one of differences within the range of normality. That the feeble-minded, for example, were not altogether neglected is well attested by the early work of Goddard [69] and Binet and others, but individuals of this type were not and never have been the primary subjects of observation by the psychologist. The first important work on individual differences in this country, that of Cattell, had as its subjects a group of college students whose normality was beyond doubt. The work started by Witmer at the University of Pennsylvania in clinical psychology was directed toward aiding the adjustment of individuals well within the range of normality.

Much as he has tried, the psychiatrist seems never quite to get away from his experience with groups of seriously disordered individuals whom, in the early history of psychiatry, he was called upon to treat

and who even to-day, in the case of many psychiatrists, constitute the bulk of his practice. It is true that a number of psychiatrists appreciate this situation and have taken steps to remedy the difficulty. Recognition of the problem is implied in the description of the mental hygiene movement by its leaders as concerned "with not only the abnormal, but with the normal." In actual practice, however, there still persists an abnormal orientation, reflected, for example, in Jarrett's [70] program which assumes nearly half the working force to be suffering from emotional maladjustment and as in need of special mental hygiene treatment. This limits entirely too much the concept of normality. It throws a pall of abnormality over the activities of half the working force and by implication over half of the general population. This is widely removed from the psychologist's concept of the average human being as a normal being. It puts the burden of proving themselves normal upon half of the population instead of assuming that he who conforms in his activities to the standards of the majority of the group is normal, whereas only those who vary extremely from the largest proportion of the workers and of the general population can be described as being in need of special consideration because of a mild or major mental disturbance.

That "the study of mental and psychological abnormalities has given the psychiatrist a deeper comprehension of processes which take place in every individual—even in those regarded as unmistakably normal," as contended by Mayo,[71] seems questionable when examined from the point of view of everyday practice in psychiatry. The prevalent attitude of psychiatry and of the psychiatrist is perhaps better stated in the words of Stevens,[71] who writes: "If something *is* wrong with the mind in industry, to whom should industry turn for help if not to the psychiatrist, with his trouble-finding outfit of 'complexes,' 'obsessions,' and 'delusions'?" Stevens has here chosen a happy phrase. It is in trouble-finding, whether it be in industry or elsewhere, that the psychiatrist seems most competent. It may even be said that he is inclined to look at human conduct through misshapen lenses, which distort the picture, bringing out the defects at the expense of the beauties—one might almost say the perfections—of human character. If the lenses, directed upon an individual, show nothing more serious, they reveal in him at least a perverted tendency to fall in love with his mother or to subordinate himself to his brother. Everything else that may be seen in the picture of the mental life of the individual seems blotted out by the psychiatrist's absorption in the abnormalities of conduct that he has observed in the psychopaths to whom his interest has until recently been largely confined.

On the other hand, the psychologist comes to industry with a common-sense orientation toward the normal, and as an observer trained in the interpretation of certain *facts* which are basic in any judgment that he may express. He comes prepared not to see primarily the abnormalities of human conduct, the Freudian obsessions, the irrational reveries, and so forth, but to study under controlled conditions normal human behavior and such deviations as may exist in well authenticated samplings, and as a result of such study, to arrive at principles of human conduct that will be applicable in the management of industry and in promoting the welfare of the human element in it.

Other important differences between the psychiatrist and psychologist could be mentioned. Among these is the inherent *objectivity of the psychological approach* as contrasted with the inherent *subjectivity of the psychiatric orientation*. The inherent objectivity of the psychological approach in the measurement of character, as distinguished from the inherently subjective approach of the psychiatrist, is well illustrated in the attitudes of the two groups toward the analysis of the so-called "personality" traits. Industriousness, ambition, application, and many other traits of the same kind must be analyzed in a complete evaluation of human personalities. It is true that there is yet no completely satisfactory method by which "the psychologist or any one else has been able to measure these traits."[72] Because they cannot now be measured is no reason for assuming, as is so consistently assumed in the psychiatric literature, that they can never be measured. In so far as these qualities may be even more essential for industrial life in many cases than are the qualities of competency, to the very same extent it becomes necessary that objective methods for their measurement be devised. The psychologist's continued absorption in the preparation of objective tests for the measurement of these traits is another expression of the faith that he places in objective instruments and of his hope for a continually decreasing dependence upon subjective judgment, such as at present must be used in observing the temperamental traits. From the point of view of reliability and validity, tests of "personality" today are comparable to our general intelligence tests of two decades ago. However, if progress in the development of these proceeds as in the case of general intelligence tests, the time may be not far distant when subjective methods for the analysis of "personality" will be relegated to the same position of unimportance that subjective methods of judging intelligence and other abilities occupy now.[73]

Regardless of whether the problem of re-adjusting workers is assigned to the clinical psychologist or to the psychiatrist, it is important that

[72] E. L. Ray, "The Psychological Versus the Psychiatric Method in Industry," *Mental Hyg.*, 11 (1927), pp. 140–47.
[73] See P. M. Symonds, *op. cit.*

supervisors, foremen, and other junior executives be impressed with the significance of individual case studies and be asked to co-operate in the study of individual workers and their re-adjustment. Perhaps one of the chief values of the operation of the Weak-Sister Committee described above, was in developing in the members of this committee of the operating force an appreciation of the importance of an individualistic approach in handling workers. Foremen, supervisors, superintendents and other minor executives cannot be expected to become experts in the classification and treatment of emotional traits, but they can learn to detect some of the symptoms. They can learn that it is possible to correct many of the milder disturbances of personality and to prevent the occurrence of major disturbances. They can become impressed with the fact that factors outside of the plant may disturb the adjustment of the worker in the plant and that these as well as working conditions, methods of work, require very careful consideration in re-adjusting the individual worker. They learn, as Smith has pointed out, that the individual represents a complex and vigorous interplay of contending forces, and that "workers very rarely fail because they intend to. They fail because they fail to do what they intend to." [74] Above all, minor executives can be taught that their co-operation is required for carrying into effect the program for individual re-adjustment outlined by the expert in the field of clinical psychology.

[74] E. D. Smith, "The Minor Executive and Mental Hygiene," in *Preventive Management* (Edited by H. L. Elkind, New York, 1931, pp. 214–217).

XXVII. PROBLEMS OF SUPERVISION AND MANAGEMENT

'E learns to do his watchin'
Without it showin' plain;
'E learns to save a dummy
And shove him straight again;
'E learns to check a ranker
That's buyin' leave to shirk,
An' 'e learns to make men like him
So they'll learn to like their work.

RUDYARD KIPLING

"For in this age of verbally managed enterprises there are not only two sorts of technics—these, by the way, diverging more and more definitely as the centuries go on—but also *two kinds of men,* differentiated by the fact of their talent lying in one or in the other direction. As in every process there is a technique of direction and a technique of execution, so, equally self-evidently, there are *men whose nature is to command and men whose nature is to obey, subjects and objects of the political or economic process in question.* This is the basic form of the human life that since the change has assumed so many and various shapes, and it is only to be eliminated along with life itself.

"Admittedly this is artificial, contrary to Nature—but that is just what Culture *is.* Fate may ordain, and at times does ordain, that man should imagine himself able to abolish it—artificially—but nevertheless it is unshakably a *fact.* Governing, deciding, guiding, commanding is an art, a difficult technique, and like any other it presupposes an innate talent. Only children imagine that a king goes to bed with his crown, and only sub-men of the monster-city, Marxists and literary people, imagine the same sort of thing about business kings. Undertaking is *work,* and it is only as the result of that work that the manual labour became possible."

OSWALD SPENGLER, "Man and Technics" [1]

"The central fact that we have to remember about the industrial system is the psychological fact that workers are human beings with wills of their own, and that, now they have become possessed through their organizations of great power in society, it is useless to say that this power ought not to exist. We must recognize their power and en-

[1] From Oswald Spengler, *Man and Technics,* New York, 1932, pp. 62–64.

deavor, by giving it full scope within an ordered social scheme, to harness it to the work of serving the best interests of society."

G. D. H. COLE

The consideration of human adjustment in industry is marked by a consistently recurring note emphasizing the significance of the quality of supervision, management and administration, in the industrial organization.[2] The antagonisms of capital and labor; the acrimonious character of labor disputes; "slacking" or "soldiering" on the job, and other expressions of conflict between workers and management represent oftimes not the faults of common "human nature" but the reflection of unintelligent leadership in industry. The executive directs and moulds his working force, and the long and powerful influence of his example and his policies determine in large measure the direction in which the "human nature" of his employees will find outlet.[3] "With the same group of workers, with the same pay, and with the same equipment, under a certain management, the workers will give their best in energy and intelligence; whereas, under another management, these workers will give as little as they can get by with, and some men may go farther and interfere where they can. A company pays the same for labor whether it is managed well or whether it is not, but what it gets from its labor depends not only upon the methods and equipment that the management provides, but upon whether the employees work with a will. This in turn depends largely upon the skill of the junior executives in dealing with human nature." [4]

THE QUALITY OF LEADERSHIP IN THE INDUSTRIAL ORGANIZATION

There is a general belief that the significance of the quality of leadership in the industrial organization has been neglected. This is particularly true in the case of first line supervision—that is the supervision nearest to the worker. As Mayo [5] has pointed out, the authority

[2] *Supervision* refers to the direct, immediate guidance and control of subordinates in the performance of their tasks. The distinction between *management* and *administration* has perhaps been most clearly stated by Sheldon who defines the former as "the function in industry concerned in the execution of policy, within the limits set up by administration, and the employment of the organization for the particular objects set before it.—Administration is the function in industry concerned in the determination of the corporate policy, the co-ordination of finance, production and distribution, the settlement of the compass of the organization, and the ultimate control of the executive.—Administration determines the organization; management uses it. Administration defines the goal; management strives towards it." (O. Sheldon, *The Philosophy of Management*, London, 1923.) In practice the last two functions are often neither clearly differentiated nor defined. The same neglect of exact terminology also appears in the literature on this topic, where the term "management" is generally used to include the functions of management and administration. This term will be so used in the discussion of problems of supervision and management in the present chapter.

[3] E. D. Smith, *Psychology for Executives*, New York, 1928, pp. 14–15.

[4] E. D. Smith, "The Minor Executive and Mental Hygiene," in *Preventive Management*, (Edited by H. B. Elkind), New York, 1931, pp. 220–221.

[5] E. Mayo, "Changing Methods in Industry," *Pers. J.*, 8 (1930), p. 331.

placed in the hands of the junior executive has usually been taken to mean that he is expected to give orders and to have them obeyed. Supervision has frequently been made synonymous with "ordering people about." The foreman, the supervisor, the junior executive at all levels, and even the chief executive, have been brought up with the doctrine that the exercise of discipline and the display of dogmatic authority constitute the outward and necessary signs of control. In the initiation of progressive personnel policies there has been a neglect of the limitations placed upon the execution of these policies by incompetent, untrained supervisors or by junior executives steeped in the traditions of old-line management. The weakness of this situation has been graphically described by Smith. "If," he says, "a man has a beautiful watch that happens to lose time, he does not take it to just any third-rate watchmaker and let him tinker with it. If a man has a Rolls Royce car, he does not leave it at any wayside garage to have its machinery repaired, or let any Tom, Dick, or Harry drive it. The finer the machine, the more skillful the man must be to repair it or to run it. It is the same situation with a factory as with a watch or a car. There is no machine more intricate, more delicate, and requiring more skillful operation, than a progressive managerial or labor policy. It is a high-speed, dangerous machine. It is better to have a simple and less progressive policy than such a policy badly directed." [6]

Attempts have been made to investigate the motives, policies, and practices of industrial executives and supervisors as a step in the formulation of a sound psychology of supervision and management. Among these is an investigation by Houser [7] who presented the following questions to chief and minor executives in many different industries throughout the United States:

"1. *What, in general, is your opinion of the problem of industrial relations?*

2. *What personnel work is done in your organization? Are its results satisfactory to you and to your employees?*

3. *What announcements have you made regarding your attitude as an executive toward your employees?*

4. *What are the policies in your organization regarding the treatment of workers by subordinate executives? Do these policies provide for the treatment of employees individually or as a group?*

5. *What methods are followed for procuring information about the observance of these policies?*

6. *By what methods are subordinate executives informed or instructed about the treatment of workers? Is instruction necessary?*

7. *How do you learn the attitude of your workers? Is it necessary or valuable to know this attitude?*

8. *What do you, as an executive, want your workers to feel about*

[6] E. D. Smith, "The Minor Executive and Mental Hygiene," *op. cit.*, pp. 198–199.
[7] J. D. Houser, *What the Employer Thinks*, Cambridge, 1927, pp. 226.

your attitude, and the attitude of management toward them?

9. *What motives form the bases of your attitudes and practices?*

10. *What obligations do you, as an executive, feel toward your workers?*

11. *Is welfare work done in your organization? What motives prompt the work? Would it be carried on whether the workers showed appreciation of it or not?"* [8]

The analysis of replies to these questions reveals a wide range of executive attitudes, philosophies, and characteristics. The most important of these may be briefly summarized as follows:—

1. *Suspicion and Fear,* probably growing out of an appreciation of the latent power of the large groups of men under their direction.

2. *Self-Satisfaction Through Power*—a love for power underlying autocratic attitudes throughout industry and representing one of the greatest forces producing individual and group frictions. It is apparent, according to the investigator, that leaders in many industries are often more eager to assert themselves in a manner personally satisfying than to achieve large returns for the organization or the maximum satisfaction of men under their direction.

3. *Self-Expression*—a trait often appearing in the form of a disregard for the expressive tendencies (of others) which might come into conflict with the desires and impulses of the executive.

4. In the *silence of chief executives regarding their attitudes and intentions to their organization* the author finds another outstanding characteristic of executive practice. The disinclination to pronounce policies, to set up standard practices, to formulate ideals of procedure, leaves to the intuition and inclination of sub-executives and individual workers policies and matters of direction which logically belong in the hands of the chief executive or of those to whom it has been knowingly and intentionally delegated by him.

5. *Disregard of social responsibilities* appears as another common characteristic of both major and minor executives. According to Houser a sense of social responsibility is "rarely found among executives governing small or medium-sized organizations. Marked evidence of such consciousness is appearing more and more, however, among the administrators of the large industries. But even the expressions of these executives usually reveal only hazy conceptions and vague emotional attitudes. Seldom does one discover a vital sense of obligation coupled with a real understanding of motives and methods which will make such an attitude truly effective." [9]

6. *Limited imagination or vision* represents another attitude frequently interfering with the executive's appreciation of the human problem in industrial management. Coupled with this is an *overemphasis on financial incentives* reflected in the naïve assumption of

[8] J. D. Houser, *op. cit.*, p. 13.
[9] *Ibid.*, p. 107.

out. It embodies none of the advantages of the direct acceptance of responsibility by the individual and the group which is necessary for the complete exploitation of the intellectual and emotional resources of "human nature" in maintaining industrial efficiency and individual adjustment.

Obedience to external circumstances having as its source of authority the man or the group, constitutes *morale*. This represents in industry a newer concept of supervision where "the group comes as rapidly as it will to a condition of awareness of itself as a working entity and imposes by itself on itself those standards of individual and group behavior which it finds necessary to impose in the interests of group effectiveness in carrying on its work." [18] The chief advantage of morale is that it produces a steadier, more persistent and, in general, less fluctuating type of behavior than discipline. Whereas discipline may break down as the result of a frequent imposition of a penalty, when punishment is relaxed, when the reward loses its attractiveness, or when a particular leader is no longer present in the plant, morale continues on. It loses none of its effectiveness because it depends not on external sources of command, but upon springs of action within the individual, growing partly out of his membership in the group, which remain active so long as conditions remain fairly constant and the unity of the group is maintained.

The substitution of morale for discipline involves a process of reeducation for both workers and executives. Only slowly can the notion of orderly conduct, growing out of the requirements of the work situation, take the place of dependence upon commands.[19] Self-responsibility cannot be suddenly vested in the group, but must be "a slow growth, built up only as executives and workers go through the actual experience of vesting explicitly and acknowledgedly in the hands of the group one responsibility after another and then helping it to fulfill that responsibility by advice and suggestion." [20] The development of morale requires a complete change in the view points of both major and minor executives who must learn to conduct themselves not as "bosses" but as leaders. It is the product not of any particular man or badge,[21] or plan, but of a direction of individual feeling and intellect toward a common objective that serves the purposes of the entire organization of which the group and the leader represent a part. Such a change can only be brought about on the basis of an analysis of the factors which influence the behavior of the "group," and through the *integration* of conflicts arising out of the existence of the group in industry.

[18] O. Tead, *op. cit.*, p. 272.
[19] *Ibid.*, p. 272.
[20] *Ibid.*, p. 274.
[21] F. C. Bartlett, *op. cit.*, p. 165.

THE PROBLEM OF THE GROUP [22]

The group represents a common factor in the industrial situation. Problems of supervision and management grow out of the fact that in industry the individual is always acting under group conditions. It is true that the individual, characterized by a specific pattern of ability, temperament, individual wants and desires, represents the human material of industry. Nowhere is his individualism completely submerged, but at no time at work is the individual freed from the powerful influence of the group.[23] The significance of these influences must not be overlooked in the attempt to formulate a scientific basis for supervision and management in industry. There seems no question that if an impulse or desire aroused in the individual is shared by his associates, that impulse becomes greatly reinforced. Even though this impulse may be opposed to the individual's own standard of conduct the influence of the group, the desire for the respect and approbation of his fellow-workers, may be sufficient to overcome the customary inhibitions against the response. Moreover, "when a common desire is intense and emotions are strongly aroused, the group of individuals who share the desire tends to become a mob or crowd in which individuality is submerged in the obsession of the common urge." [24]

In industry there are many common points of view and desires, referring to such factors as working conditions, treatment by the management, methods of payment, etc., that are exposed to frequent stimulation.[25] So similar are these interests that the denial of the rights of one member of the group may be taken as a denial of the rights of the entire group and lead to serious conflict in the industrial organization. Conversely, the satisfaction of the demands of a single individual or the adoption of what the group feels to be a desirable attitude affects the entire group and becomes a source of continued harmony. In other words, crowd spirit may become a force not only for conflict, but for loyalty and for industrial solidarity and effectiveness if harnessed to objectives which truly serve the purposes of the group and of the industrial organization.[26] "The power of crowd desire, like the power of individual desire, thus is a power that may be good or evil. The blind power of aroused crowd desire is so great and so blind, its symbolized conviction is so incontestable, and its indifference to conse-

[22] A very readable discussion of the effect of the group in industry is to be found in E. D. Smith's *"Psychology for Executives,"* Chapter 6. For an early approach in the interpretation of group conduct, the reader is referred to G. LeBon, *"Psychology of the Mob,"* London, 1908, pp. 239. For a more recent point of view he is referred to F. A. Allport, *"Social Psychology,"* Boston, 1924, pp. 453, and for a less technical discussion, to E. D. Martin, *"The Behavior of Crowds,"* New York, 1920, pp. 312.

[23] E. D. Smith, *Psychology for Executives,* pp. 162–163.

[24] *Ibid.,* p. 164.

[25] *Ibid.,* p. 165.

[26] *Ibid.,* p. 174.

quences other than the achievement of its own ends is so complete, that it is dangerous in any situation where there is any need for criticism or determination of goals. As most problems of industrial relations are problems of determining goals, their successful solution is greatly aided by the avoidance of crowd emotionalism. Valuable as is the ability of an executive to arouse and direct crowd feeling toward the good of the whole, it is certainly as valuable to be able to keep the relations of his employees to him and to the company free from destructive crowd spirit." [27]

One of the outstanding characteristics of group activity is the heightened suggestibility of individual members of the group. According to LeBon,[28] an individual involved for some length of time in crowd action soon finds himself in a state closely resembling that of the hypnotized individual. As the latter, under the influence of suggestion he will undertake to accomplish certain acts with irresistible impetuosity. The influence of the suggestion is the more irresistible because being the same for all individuals in the crowd, it gains strength by reciprocity. The individuals in the crowd strong enough to resist such suggestion are too few to struggle against the current. Its effect was frequently observed, for example, during the War, when if in the course of a retreat a single soldier threw himself on the side of the road and gave way to an attack of "nerves," in an hour or so 100 men would be found in the same plight.[29] Its force is particularly apt to be felt under the influence of fatigue, under conditions of strained attention, heightened emotion, limitation of free bodily movements, etc.,[30] but increased suggestibility is at all times present as a powerful factor in giving direction to the activities of an individual in a group.

The tendency to designate facts by symbols represents another factor in group activity.[31] So, for example, "fourteen points" becomes a symbol for the identical attitudes and activities of the group engaged in the common behavior of fighting the Germans. The silk hat and the swallow-tail coat serve as symbols of a capitalistic economy and as such find no place in the communistic regime of Soviet Russia. The college trained man is made to represent to a group of workers a symbol of the denial of their chance to break through into supervisory jobs, and the employment of such men may become the focal point for serious conflict between the worker and management. The number of such symbols is legion, and their effect cannot be over-estimated in considering the sources of industrial conflict, and procedures for the formation of morale.

The crowd's thinking tends to construct an imaginary world of

thought forms and to take refuge in its ideal system. Attention is focussed upon the abstract and upon the general. There is no place for logical thinking in the solution of its problems. "Catch phrases" and "magic formulae" are substituted for scientific information. The truths of the crowd are "given,"—made in advance, axiomatic, requiring no proof and not open to question in the minds of the crowd. Systems of general ideas are imposed upon the minds of the individuals constituting the crowd from without, and universal acceptance is demanded. Thought becomes stereotyped—conforming to a system designed to cater to the desires and self-feeling of the crowd.[82]

The tendency for the whole mass of feelings and ideas to work itself into a "circular system of thought" is characteristic of crowd activity. Repetition and rehearsal by members of the group gradually work glittering generalities and emotional outbursts into a creed. "The fixation of crowd attention by common consent, almost by common compulsion, and the use of stock phrases with their halo of antiquity, bring about a sense of incontestable conviction.—With this incontestability of the crowd creed goes a sense of self-righteousness and exaltation. Because his suppressed wishes assume a validity they do not have when he is alone, an individual always feels temporarily magnified when in an active crowd. What is desired has changed into what is right. And from this union of desire and right grows not merely exaltation, but also great determination and perseverance. The individuals compete with each other in serving the crowd end. They endure hardship, suffering, and danger with joyousness. They are indifferent to any consequences, except to those relating to the polarizing purpose of the group. Thus people perform acts of heroic devotion in time of war that they would do at no other time. Nor do they stop at the customary moral scruples any more than at danger to themselves. Crowds containing otherwise respectable people have gloried in the righteousness of burning at the stake negroes who have never been proved guilty of any crime. An actively aroused crowd of this sort—and we have abundant examples of such on both sides in industrial as in political warfare—is blind, fearless, and unscrupulous in its devotion to its incontestable right." [83]

The extreme intensities of crowd spirit are, of course, only attained by mobs, and, occasionally, by workers on strike. However, the same influences are present in milder form in groups of workers at all times, and contribute in arousing conflicts which must be resolved as a step in substituting control from within for discipline from without in the development of new forms of supervision and management in industry.

THE INTEGRATION OF CONFLICT

Industry offers many opportunities for conflict between groups of workers with similar desires and the policies and practices of manage-

[82] E. D. Martin, *op. cit.*, pp. 137–142.
[83] E. D. Smith, *op. cit.*, pp. 166–168.

ment. Conflict, as Follett has pointed out, is not necessarily undesirable. It is not always open warfare, but an expression of differences—differences of opinions, interests, desires, etc.—an interaction of desires.[34] In the form of rivalry among industrial organizations conflict has unquestionably contributed to the improvement of management and of operating techniques and to the general development of American industry. As competition among individual employees, and as the clash of opinion in committee meetings and executive conferences, it has done much to prevent stagnation and to bring about improvements in methods of work. Disagreement between labor unions and employers has been a potent force in bringing about better conditions of work and in raising the general standard of living in the American population.[35] Conflict becomes a pernicious influence only when it becomes an end in itself; when it is used to secure the domination of one group without respect to the justice of the situation. The desirability of conflict depends too upon the way in which it is resolved—whether it is ended by a solution that is mutually satisfactory and that really strikes at the root of the difficulty, or whether it leads to a compromise that merely sets the stage for the recurrence of the same conflict, at the same level, with the same objectives, with perhaps only a change in the name or symbol of the conflict.

The chief danger of group conflict, as of individual conflict, lies in the unhealthy attitude and behavior tendencies which become associated with the conflicting impulses. It has been pointed out that in the individual the conflict of submerged desires and impulses often leads to a disturbance of personality.[36] The fault finding, the petty jealousies, and suspicion of the worker follows from a lack of harmony among contending impulses and motives. The effect of conflict of this type is to be found not only in the case of workers, but is reflected in the "dominating" attitudes of supervisory and executive personnel. It is particularly apt to develop when opposing tendencies are submerged, repressed, or blocked in their expression. The same principles are active in the case of group conflicts. The submersion or the failure to establish a harmonious balance between the desires of workers at points where they conflict with those of management produces a distortion of attitude and of behavior tendencies. "The primitive reaction flowing from such a group conflict . . . ranges from a mild emotional fixation to an intense passionate fury that leads to physical violence and indifference to punishment. It may be acute as in a strike or chronic as in a smoldering dispute. The conflict may be open as in a strike, but more often is submerged, manifesting itself primarily in a quiet but thoroughgoing effort on the part of the employees to give as little as possible

and on the part of the management to squeeze as much out of the workers as possible. . . . Even when the primitive attitude which destructive conflict between the employees and the company engenders does not result in sabotage, or conscious soldiering, the wastes are large Even at low ebb, such a conflict is a complete obstacle to securing voluntary effort. . . . All effort which is sought from labor must, under such conditions, be compelled by fear of discharge or by hope of award, and the cost of compulsion of unwilling workers is high. When antagonisms between the employees and the company are aroused, just as when wishes rebel within the individual mind, much energy is consumed in the mere neutralization of opposing forces. The company pays as part of the price of such a conflict, however, not merely the cost of compulsion, but the loss of all results that cannot be compelled." [37]

Conflict is most destructive when contestants seek to dominate one another as the only available means of securing the satisfaction of their desires. Domination is a victory of one side over the other. At the moment of conflict, this generally *appears* to be the easiest way of dealing with it and, for this reason, domination is the method most frequently adopted for its solution.[38] The urge toward *domination* may be brought about by a variety of circumstances. The refusal to recognize or to deal with an employee or a union may produce a situation in which an attempt to establish the supremacy of the union may appear to employees as the only method of expressing their desires. Gruff, arbitrary orders may lead to an inversion of feeling that may ultimately find expression in the attempt of the employee to show his control of the situation by means of a strike or other concerted action with his group. Unsatisfactorily worded and public reprimands play a part in the quest for dominance. Fear of losing the job because of an unreasonable attitude on the part of minor executives is a fertile source in workers of the urge to dominate. Unfair regulations of all kinds, supplemented by an arbitrary use of discipline, often block outlets to impulses and arouses conflict of a pernicious type. Such situations are generally intensified by the crowd spirit. In all of these are found the sources of the struggle for a victory as empty of meaning and value, in industrial conflict, as the victory of the "war to end war" in the political arena.

Compromise represents a second method of dealing with conflict. In this type of settlement each side gives up a little—makes concessions—in order that the activity which has been interrupted may go on. Compromise is the basis of trade union tactics and, in most instances, underlies solutions reached by arbitration. The danger of compromise, as Follett [39] has pointed out, is that it will arise again in another form. Compromise involves a sacrifice of desires. There is no real satisfac-

[37] E. D. Smith, *op. cit.*, pp. 178–179.
[38] M. P. Follett, *op. cit.*, p. 115.
[39] *Ibid.*, pp. 115 ff.

tion for both parties to the controversy, as the result of the formulation of a solution adequate for the total situation, but merely, in essence, a postponement of the struggle until one or the other side considers itself strong enough to renew it.

The only completely satisfactory method of dealing with industrial (and other) conflicts, according to Follett,[40] is that of *integration*. The procedure is essentially the same as that used in the re-adjustment of the individual. It involves an analysis of the "whole situation" and an attempt to balance the conflicting impulses so as to produce a new "whole" or pattern which will adequately meet its needs. In accomplishing this, the situation cannot be surveyed separately from the view point of management, and then again as a distinct problem from the view point of the workers. The attempt must be made to view the needs and desires of workers and management in relation to one another, and to arrive at a solution which will permit an adequate satisfaction of the desires of the two groups in a way that will be beneficial to the organization as a whole. It requires a wide range of "simultaneous attention" to the whole situation as a means of observing the relationships within it; of contriving a solution in the light of this total situation which knits contending desires and of establishing this solution as a reality.[41]

The underlying approach in this viewpoint is that of the "gestalt school" [42] in psychology, broadened to apply to social entities or configurations. The emphasis is upon the "integrative unity" of the industrial organization. It is based upon the belief that the "parts of a business should so move together in their reciprocally adjusting activities that they make a working *unit*, not a congeries of separate pieces." [43] Unity is created by the functional relations of the parts, by the "reciprocal activity" of the parts and not merely by a summation of the elements or parts of the whole. The character of the whole is also affected by the interrelations of the whole and the parts. Out of this interaction and unification *emerge* new patterns—new integrations, which are the earmarks of progress—a "self creating" development of the organization. So, for example, the production, sales, financial, and personnel policies of an organization influence one another. At the same time, the *general* policy created by the interweaving or interaction of all of these policies, even while it is in the making, influences and changes each of them. In other words, individual departmental policies are influenced by the general company policy which they help to create.[44] And out of the interaction there gradually develop new poli-

[40] *Ibid.*
[41] E. D. Smith, *op. cit.*, p. 208.
[42] W. Koehler, *op. cit.*
[43] M. P. Follett, "Psychology of Control," in *Psychological Foundations of Management*, (Edited by H. Metcalf), Chicago, 1927, p. 165.
[44] *Ibid.*, p. 168.

cies—departmental and general—which represent a progressively improved adaptation to a changing environment.

Follett has made a broad application of the viewpoint to the settlement of conflicts between workers and management. "If," she writes, "we want a settlement which will mean progress, greater success for our business, we shall try to include the values of both sides, which will give us more than the values of the two sides added together, will give us an emergent value. Our outlook is narrowed, our chances of success are largely diminished, when our thinking is constrained within the limits of an either-or situation. We should never allow ourselves to be bullied by an either-or. We want to learn how to make any human association most effective, most fruitful. . . . When employers and employees are willing to sit down together to try to solve their problems rather than to bargain on the basis of who possesses the greater economic power of the moment, then we shall be on the road to settling 'the labor question.' That genuine authority arises spontaneously within the process of building up an integrative unity should be the argument for employee representation, not that it is the 'right' of the workman nor because it will ease up things for the employer." [45]

Integration is not an easy matter in the case of conflict within the single individual. It becomes an extremely complex problem in the case of the industrial organization, in which there are contending groups brought up on habits of considering narrow interests and the methods of everyday argumentation and contention. A first step in integration involves an exact determination of facts. It permits a free and unlimited expression of contending view points. It is carried through in an atmosphere free from the subservience of one individual or of one group to another. It often involves the use of an advisory instead of an executive set-up as an agency for considering facts and freely expressed opinions as a basis for executive action. It devotes itself first and foremost to an analysis of underlying conflicts as a way of contriving a solution that will adequately serve the needs of the total situation. The agency most frequently employed in industry as a means of substituting integration for domination is some form of employee representation, in the form of a "shop committee" or "works council," an "organization under which the employees of an individual establishment, through representatives chosen by and among themselves, share collectively in the adjustment of employment conditions within that establishment." [46] The history and character of such agencies cannot be reviewed here.[47]

Several American firms, including the Nernst Lamp Co., of Pittsburgh, the Nelson Valve Co., of Philadelphia, had experimented with employee representation plans in the first decade of the century. However, the movement received its great impetus in Great Britain from reports prepared by the Reconstruction Committee and Subcommittee on Relations between Employers and Employees (1917), commonly know as the "Whitley Committee." [48]

Numerous representation schemes have since been adcpted both here and abroad. These have failed in some instances because of the type of organization employed; in others because of the dishonest use of representation as a cloak for autocratic methods. More frequently they have not succeeded because of the failure to educate workers and management in the underlying philosophy and techniques of integration. The solution of conflict by integration involves the establishment of new habits of thinking and new ways of acting for old patterns of thought and behavior. It requires a long apprenticeship in which respect for facts, the willingness to accept the motives of others as honest and sincere, and the techniques of discussion on an intellectual plane are gradually developed in both the worker and management group. "Integration is an achievement that requires skill and effort. It is much easier merely to see what should not be done and prohibit it than to discover what fundamental desires will thereby be deprived of outlet and devise ways of providing them with useful forms of expression. It is easier to command than to bring about a common understanding. To integrate is not easier, but temporarily at least, more difficult than to rule by sheer power. The value of integration is not that it makes present solution simpler or easier—its value lies in the better quality of the solutions, even though more difficult to attain. To learn how to integrate makes life or management not easier, but better and richer. . . . Orderliness and control are essential in the individual mind and in complex modern factories. Centralized inflexible discipline secures orderliness and control, but does so at the price of repression and the disintegrating evils of submerged rebellion. Integration combines orderliness and control with freedom. It adds to the blessings of well-articulated operation, the power of voluntary co-operation and joint contrivance. It develops the character of an industry, and through the development of its character, the character of all who are engaged in it. To the extent that an organization or personality is through skillful integration at peace with itself and its elements employed in the service of the whole, there come stability, power, and poise." [49]

THE NEW LEADERSHIP IN INDUSTRY

The substitution of morale for discipline and of integration for domination calls for a change in the quality of leadership in industry.

[48] G. S. Watkins, *Labor Problems*, New York, 1929, p. 630.
[49] E. D. Smith, *op. cit.*, pp. 241–243.

Bartlett [50] has distinguished among three types of sectional leaders found in a complex social organization such as an army, viz.:

1. those who maintain their position mainly by virtue of the *prestige* attached to the office;
2. those who maintain their position because of their capacity to *impress* and *dominate* their followers;
3. those who maintain their position by reason of their personal capacity to *express* and *persuade* their followers.

These may be respectively designated as the *institutional*, the *dominant*, and the *persuasive* types. Examples of each are likewise to be found in industry. Craig and Charters [51] have listed, as follows, the qualities characteristic, to varying degrees, of these three traditional types of successful executives in industry.

Forcefulness
Ability to command respect
Impartiality
Control of temper
Personal interest in the men
Ability to train them
Ability to give clear and detailed instructions
Ability to follow up and see that instructions are carried out
Ability to get and use suggestions of subordinates
Ability to get teamwork
Ability to praise wisely and reprimand effectively
Ability to create a spirit of accomplishment
Ability to develop enthusiasm when that is desirable
Self-confidence
Ability to develop self-confidence, particularly in the new employee

The integration of conflict requires a type of leader not included in Bartlett's classification and endowed with qualifications not explicitly mentioned in the list given above. He must depend not upon prestige, dominance, or persuasion, but upon the capacity to integrate the abilities and desires of individual members of a group to a common purpose.[52] He is a leader who recognizes that in the liberation and use of the diversity of individual capacities, planning, foresight, and desires, lie the best guarantee of collective efficiency and power. He is an executive who appreciates his responsibility by effecting "a constructive and integrating growth" of his group,[53] and agrees, in thought and deed, with Follett, that "our generation—is contributing something to the history of thought in this matter of human relations and—that business men have the opportunity to share largely in that contribution.

[50] F. C. Bartlett, *op. cit.*, pp. 138–139.
[51] D. Craig and R. Charters, *Personal Leadership in Industry*, New York, 1925, pp. 235–36.
[52] W. Burnham, *The Normal Mind*, New York, 1925, p. 40.
[53] W. V. Bingham, "Leadership," in *Psychological Foundations of Management*, p. 26.

Academic people may hope that what they are teaching will be followed by their students, but business men can actually themselves put into practice certain fundamental principles. They may be making useful products, in addition to that they may be helping the individuals in their employ to further development, but even beyond all these things, by helping in solving the problems of the organization, they are helping to solve the problems of human relations, and that is certainly the greatest task man has been given on this planet." [54]

[54] M. P. Follett, "Leader and Expert," in *Psychological Foundations of Business Management*, pp. 242–43.

THE END

ACKNOWLEDGMENTS

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